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Improving accessibility at airports

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ABSTRACT

This paper makes a contribution to existing attempts applied to improving the accessibility at airports through an abstract aggregated approach in modeling the geography of air passenger flows. A region gathering Hungary and its surrounding administrative regions is used as a case study; the traffic of air passengers flying to twenty-two international destinations and through the six main airports in the region are modeled. The performance of the calibrated model proves to be consistent with the current share and total air passengers flow in the studied region. Furthermore, several scenarios highlighting completely different approaches, including geopolitical and economical issues, are considered to model and predict behavioral changes in the air traffic. Results suggest and stress how important connectivity is above price and time parameters when modeling the airport choice in a multi-airport región. In future applications, the route selection, the "catchment area" delimitation and the airport's business model are suggested to be solved through a disaggregated modeling approach.

Key words: Abstract aggregated modeling approach, Multi-airport region, Airport competition, Airport choice modeling, Catchment area.

RESUMEN

La presente tesina contribuye al estudio de la mejora de la accesibilidad a los aeropuertos a través de la modelización de los flujos de pasajeros aéreos mediante un modelo discreto agregado y abstracto. La zona geográfica que comprende Hungría y las regiones administrativas que la rodean, se considera como objeto de estudio; se modela el tráfico de estos pasajeros entre los seis principales aeropuertos presentes en dicha región y veintidós destinos internacionales. El modelo calibrado se ajusta tanto a la repartición actual como al volumen total de pasajeros aéreos que circulan a través de cada uno de los aeropuertos considerados. Por otra parte, se presentan varios escenarios basados en distintos planteamientos para modelar y predecir los cambios en la demanda y el comportamiento del tráfico aéreo. Asimismo, se examina la importancia de componentes económicos y geopolíticos que puedan significar una alteración considerable del flujo de pasajeros aéreos en la zona de estudio. Por lo que refiere al modelo de elección de un aeropuerto en una región multi-aeroportuaria, los resultados corroboran la importancia de la conectividad por encima de otros parámetros como el tiempo y el precio. En estudios posteriores y a través de un modelo desagregado, se sugiere indagar en la selección de las rutas de acceso a los aeropuertos, en la determinación de la zona de captación y en la importancia del modelo de negocio de un aeropuerto en su .

Palabras clave: Modelo de elección agregado directo y abstracto, Región multi-aeroportuaria, Competencia aeroportuaria, Zona de captación.

INDEX

FIGURES INDEX

TABLES INDEX

1. INTRODUCTION

1.1. Connectography

"Geography is destiny". It's not only a common saying but a given concept that we have probably internalized deep down ourselves as a matter of historical trends. Nowadays, it just tells us that landlocked countries won't scape poorness, that large countries will prevail among surrounding smaller neighbors and that huge distances are unbeatable. Believe it or not, this statement is no longer valid. There has never been such a strong and non-refutable argument against it. Connectivity is the actual force that fuels human species' progress. "Connectivity is destiny" (Khanna, 2016)

Let's try to sort it out. Forget about the borders, countries or flags. Think of a world with unrestricted movement all across itself as of a tree with a never-ending flow of nutriment through its vessels. Think of the nutrients as people, knowledge and resources all running through the connections, the vessels, filling dots in space spreading wisdom and richness.

World's current infrastructural connection consists of about one million kilometers of railways and sixty-four million kilometers of roads (Central Intelligence Agency, 2013), regarding to transportation. And this is actually expected to increase in the very coming years. International borders, on the opposite, total in 251.060 kilometers (ChartsBin statistics collector team, 2010), approximately. It's no surprise the world is heading to improving connectivity as a way of strengthening social and economic ties. It is supposed that we are going to invest in infrastructure in the next forty years as much as we have done in the past four thousand years (Khanna, 2016) and the ones reluctant to such an evolution progress are condemned to fall apart.

Connectivity is a reality that has shaken the world as we have known it. The global connectivity revolution in every and each of its forms is responsible for boosting an unstoppable flow of people, knowledge, goods and resources that mean nothing but the basis of welfare and progress. Geography has been forced to step aside when just shaping the future. Instead, both connectivity and geography can define together what's ahead. "Connectography" (Khanna, 2016) is the answer. It leads us to another concept arisen simultaneously. Cities are the infrastructures that most define us, and by 2030, it's expected that more than two thirds of world's population will live in cities.

Megacities now play a more important role than the countries that limit them geographically. Economic and social connections jump across international borders and make evolution happen. That is why, in some cases like Sao Paulo (Instituto Brasileiro de Geografia e Estatística, 2015), the GDP of a city may exceed the third or even the half of the total GDP of the country. What if we stopped grading the world by territorial limits and started focusing on the main development clusters and their connections as the vital organs and vessels that power up a body called planet? In a megacity world, countries can be suburbs of cities. Yes, the earlier we adapt to it the greater the income for the society. World's connection network is being constantly resized on its own as you may have never figured out and that is something we do not just need to accept but to embody to make the most out of it.

Yet we have to consider that "connectography" (Khanna, 2016) remains incomplete without understanding the role of the flows of people, of finance, of technology that enable them to thrive, connections to others. Even more considering that, nowadsays, countries and megacities are more concerned about building connections and investing in other countries' connections rather than particular disagreements. And that's an awesome step forward. Burying the hatchet and building together seems to be the best way to move forward. And by enfolding the world in such harmonious physical and digital affinity, people can rise above their geographic restrictions.

As a matter of fact, Budapest has the roots and raw materials to become a megacity by the next decades. It is set to be an Eastern-Europe hub. It will just be a result of unifying efforts and moving towards connecting the city in all the possible ways. It is a gifted place in the world that needs to be pointed in the map as a consequence of its greatness instead of proving the opposite by setting obstacles.

However, we have come a long way to get to that point. As it was marked (Jobs, 2005) "you cannot connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future." Let's throw it back to the origins of the geography of the air transportation and the way it has helped to shape "connectography" (Khanna, 2016).

1.2. Geography of air transportation

Geography and air transportation have always been intrinsically related. Now "connectography" (Khanna, 2016) is as well. The individual geography and demography of a particular region has a massive impact on the air transportation growth, as airports tend to become specialized based on business models that will be introduced later. However, air transportation has also an effect on the previous two.

People's aim of achieving recognized objectives at destinations unaccessible in the origin (Borgstrom, 1974) makes traffic happen. It is suggested (Ullman, 1956) and used as a study basis, that the gravity model approaches quite fairly the traffic modeling between two places. It is a function of their "masses", mostly depicted by the population's size, the attractiveness of the destination, the geographical distance that keeps them both away and interceding opportunities. The population size, the attractiveness of the destination and the interceding opportunities have a positive impact on the traffic as they increase. The geographical distance among them has a negative impact.

Simultaneously, fulfilling people's travel needs between two given places through encountering the shortest and best transportation routes has been and continue to be one of the foremost concerns of geographers. The main challenge is to represent the negative exponential that opposes the traffic flow in the gravity model.

With the emergence of the hub-and-spoke structure, all together have endured the interests in the accessibility and network analysis within transportation geography. Grading hubs and its activities level has been deeply examined in United States (Ivy, 1993;

Reynolds-Feighan, 1998), Europe (Button & Stough, 2000; Graham & Guyer, 2000) and the other parts of the world (Bowen, 2000; Feiler & Goodovitch, 1994). Furthermore, the operations of airlines at a regional level have been studied by Reynolds-Feighan (2001) and Shaw (1993), among some others.

Unfortunately, geography of transportation has not been fully committed to the study of flows of air passengers among competing airports in the same metropolitan region. And they do have a hard effect on the others development and success. Twenty-six multi-airport regions within the same metropolitan region were listed in 1995 (Neufville, 1995). Some of them include Los Angeles, New York and London, whose airports are closer than 150 kilometers from each other. Is is also suggested that multi-airport regions are expected to happen in metropolitan regions with over ten million air passengers (Loo, Ho, & Wong, 2005). Note that increasing the amount of airport terminals can also help to the metropolitan region to afford demanding air passenger's flows.

Also, "the fact that airports associated with different cities and jurisdictions can be part of the same multi-airport system needs to be stressed." (de Neufville, 1995, p. 100). At a wider regional scale, Pels et al. (2000, p. 29) highlighted that there existed "airport competition in a broader region, i.e. competition between Amsterdam, Brussels, Frankfurt, Paris, and London". An other good example might be Hong Kong, Shenzhen, Zhuhai and Guangzhou (Loo, Ho, & Wong, 2005).

Dots start to connect. Such a multi-airport region's growth does not happen by chance. There are several reasons that help to explain it. First of all, the origin-destination concept has been redefined empowering a centralized network on major hub networks (Burghouwt & Hakfoort, 2002). Hubbing operations together with the hub-and-spoke development have led to massive savings for airlines. Simultaneously, the level-of-service (LOS) factors are now determinant for air passengers to choose the airport where to fly from despite not being the closest option. A better service, more direct commercial flights, cheaper air fares (even spending more travel time) and particular airlines now have some weight in people's airport choice. And as time goes by and almost everyone has a clear access to take a flight, the competition in the air transportation branch is getting tougher. In a multi-airport region, "people can and do make a choice as to which airports to fly from based on the relative service offerings at competing airports" (Brooke et al., 1994, p. 37).

The LOS factors are not only important for airlines but also for airports to help them prevail in this hard duel. In example, Barcelona (Aeroport del Prat) has few direct connections to any airport of New York City. However, european hubs like Stockholm or London where Norwegian Airlines and British Airlines are settled, offer a good range of flights connecting Europe and New York City. In most of the cases, it leads to a cheaper fare flying from London or Stockholm to New York City instead of flying straight from Barcelona. The point in that example and just chosen two out of a lot more cities, is that London and Stockholm not only compete in direct connections among regional destinations but they do it as well for indirect connections where those airports are used as hubs of global importance. The "theory and the analysis of practice indicate that the pattern of traffic distribution among multiple airports in a region is determined by the dynamics of competition among the airlines and airports" (de Neuville, 1995, p. 99).

Of course, now the level-of-service factors of both of them and not only the air fare, determine the chosen one. Vast distances are no longer vast and the "catchment area" of an airport seems to have no precise limitation. It is argued that the multi-airport region concept "is a definite shift from past thinking, when airport planners generally assumed that airports served "catchment areas", that the Baltimore airport only served Baltimore, the Washington airports only served Washington, and so on" (de Neufville, 1995, p. 100). Unfortunately, it may be a failure to simplify assumptions of pre-defined catchment areas and used aggregated approaches that may not be as accurate as a continuous equilibrium modeling approach, in example. However, it still can assure a first grasp and provide some helpful and valid data in a basic study, as it is argued in this paper.

As mentioned before, airports are understood as general facilities that provide different services and upgrade people's journey instead of a mere temporal "pit stop". The majority of passengers can choose from two or more airports. As time goes by, consumers have more and better information and the market proves being sensitive to the prices. It now seems clear that the shortest Euclidean path or the fastest route between passenger's home and the departure or the arrival airport is no guarantee for a route to be chosen. Furthermore, "secondary LOS factors tend to dominate in a multi-airport context when differences in physical distances among competing airports are not great" (Bradley, 1998). It was also suggested that the main LOS factors include air fare, access modes, travel time to the airport, timing of flights, airport congestion, extra journey time for transfer, airlines services, parking facilities, check-in facilities, ancillary airport facilities (like shops), transfer facilities, and baggage (and immigration and customs) facilities (Bradley, 1998). Among all of them, air fare happened to be the most essential variable in the study. However, it may vary in every possible scenario. It is an issue but still real that London Heathrow Airport and Cluj's International Airport, in example, cannot be put in the same conversation when studying the weigh of each of the previous variables. They both refer to different economic clusters, to different ground accessibility, to a vast different amount of operating airlines and destinations provided and, more important, to different cultures and populations. This is why the importance of LOS in every scenario may vary upon the current conditions that shape it.

Secondly, the development of high-speed railway connections together with expressways is linked to the never-ending spatial spread of population and economic activities far beyond city or country's ties. A concept known as extended metropolitan region (EMRs) in urban geography (Ginsburg, 1990). A metropolitan area is self-defined administratively and function as an individual entity. Note that such region has derived from a highly efficient ground transportation system. In the current study, it will be treated deeply as it is one of the main issues currently. As we can see, "connectography" (Khanna, 2016) is present even at a regional level.

Finally and as it has been bolded by O'Connor and Scott (1992, p. 241), "an airport is perhaps the most important single piece of infrastructure in the battle between cities and nations for influence in, and the benefits of, growth and development". Spending money in development towards strengthening relations and connections with other regions is almost in every single government's "to-do list". Airport facilities can support export-oriented industrialization, tourism and international business and so they can catalyze and drive business development outward for many miles. And not less important, they serve as the physical interface where the global meets the local.

It all has paved the way for current studies about air traffic flow but, as it was mentioned before, connections are constantly reinventing themselves. Geographical distance is no longer so determinant, the attractiveness and the opportunities of a destination may vary upon time based on the current economy or even political policies. Furthermore, the total population of a region is not that accurate when predicting traffic as the study goes deeper. Is anyone willing to travel? Can anyone afford it? Are people's likes and preferences considered when choosing the mode of transport? Does the kind of regional development and, consequently, regional population profile matter? Yes, of course. Loads of considerations need to be taken into account and that is what has pushed forward the air traffic modeling approach in a better way through the recent years.

Some of them are external factors such as the GDP, contribution of the tertiary sector to the GDP, population density, unemployment rate, etc. The truth is that all those external factors may vary upon time. However, the performance of aviation robustly correlates with the population density and the development of various Central-European regions. In case of non-airport cities, it seems proportional de necessity for aviation with the population density. On the other hand, those external factors have less impact on air traffic flow in "airport cities" as Charleroi, for example. Nonetheless, they can help to offset the weaknesses of the GDP and the lower population density in terms of aviation at least at a certain degree.

Every time more and more airports are tending to become specialized. The variations can be interpreted based on a number of business models. It is a huge factor for an airport's "success", even more in a multi-airport region. The differentiation from the others needs to be crystal clear to overcome any sort of lack of traffic. Those to be considered are the airport network as a co-ordinated airport group, hubs of global, airport cities, a multi-modal airport, the airport as final destination, business terminals, "low Cost" terminals and freight platform.

In the present paper, most of the airports investigated as a matter of study are still redefining themselves. Some of them as a result of the increasing amount of new air routes and destinations in the very last years, the competitive fares they provide and attractiveness they are generating. However, yet they are partially "low cost" terminals that foster direct routes inside of Europe but require a major hub of global importance to reach further destinations. In order to afford a quantum leap that helps them become an economically successful airport, some headlines that they should meet are; a minimum volume of traffic, limited of minimum ten million for passenger transport, a good positioning, a clear business development strategy, an appropriate economic background as the opportunities to diversify services and good enough connections with the surrounding environments.

2. RESEARCH PROBLEM AND THE ROLE OF BUDAPEST LISZT FERENC INTERNATIONAL AIRPORT IN THE REGION

During the 20th century, Hungary's geopolitical position was re-evaluated several times. The size and the country's borders changed as well, mostly shrinking. Furthermore, the position of the country in its encircling environment and its regional and continental power status never ceased changing.

Entering the 20th century, Hungary or more precisely, the Lands of the Holy Hungarian Crown, was part of the Austro-Hungarian Monarchy, had its recently new capital Budapest (after merging Buda, Pest and Óbuda) as a great economic cluster and its dominance area included the current North of Serbia and Croatia, the Southern region of the current Slovakia, a vast region in Romania, Transylvania and South-east of Ukraine, the also known as Ruthenians (Zoltán, 2004).

After the World War I, the Treaty of Trianon[1] lowered significantly the influence of Hungary in Europe. The agreement between the Allies of World War I and the Kingdom of Hungary, regulated the status of an independent Hungary state and its borders were redefined. During the war, Croatian and the Slovaks declared their independence from Hungary and Romanian troops declared war upon the eastern part of Hungary. After the Treaty, it ended up losing two thirds of the former Kingdom's extension to the newly created surrounding countries and leaving a 30 percent of the ethnic Hungarians living under foreign territory. The status of Hungary was seriously affected as five of the pre-war ten largest cities of the region were drawn into other countries (Zoltán, 2004), leaving Hungary as a landlocked state empowering the formers Kingdom of Romania, the Czechoslovak Republic and the Kingdom of Yugoslavia, none of this status still alive.

After many revolutionary years sparked by such a massive shake in the region, the Southern Slovakia mainly populated by Hungarians and Ruthenia, were both incorporated into Hungary by 1938. A couple of years later, the northern half of Transylvania did the same. By the next, Vojvodina, the Northern region of Serbia was brought back under the Hungarian influence. Nonetheless, this process of re-annexing former Hungarian regions was left into dust by the end of the World War II.

During this period, Hungary antagonized both the Soviet Union and the United Sates of America, a fact that set the tone condemning it for the years to come. Moreover, despite being an island of peace and safety in Europe before entering 1944 and siding with the Axis Powers, the Germans finally occupied Hungary and diminished most of it leading to a Nazi Government short before the Soviet occupied ("liberated") the country after a terrible siege of Budapest by 1945 (Rainer, Bekes, & Byrne, 2002).

By 1956, the Revolution (Rainer, Bekes, & Byrne, 2002) broke out to be soon crushed by the Soviet troops. This fact meant the consolidation of the communist regime in Hungary for the next 32 years. Hopefully and as time went by, exit visas to leave the country for

[1] Treaty of Trianon, (1920), treaty concluding World War I and signed by representatives of Hungary on one side and the Allied Powers on the other. It was signed on June 4, 1920, at the Trianon Palace at Versailles, France (The Editors of Encyclopædia Britannica, 2016)

either touristic or scientific purposes were more and more common. Despite not being automatic, it helped to introduce a relative freedom and a wider and open-minded thinking that the former Socialism did not work. Since then, Hungary became a republic as a result of the ruling Communist party handing over the power by 1989-90 and withdrawing all of the Soviet troops that stationed in Hungary (Békés & Kalmár, 1999).

From then on, Hungary and other developed socialist countries such as Czechoslovakia and Poland, reportedly showed their intentions to join the EU. Hungary was finally introduced by 2004 after a period in which European stability was shaken due to Yugoslavian crises, among others. Before entering the EU, Hungary strengthened relations and built connections with surrounding countries by taking part in the "Viségrad Group[2]", in the Warsaw Pact[3], in the EFTA[4], retaking diplomatic relations with the NATO[5] and the European Economic Community (EEC[6]).

Note that the neighborhood policy has always been emphasized. Regarding to the Southern part of the region, the independence of Croatia and Slovenia by 1992 was firstly acknowledged by Hungary, among others. It partially sided and sealed diplomatic relations with both of them in the Yugoslavian crisis and tensed the relations with Serbia (Zoltán, 2004). The air war of the NATO against Serbia by 1999 did not help at all in this fragile situation among both countries. In the north and by 1993, the former Czechoslovakia happened to split into the Czech Republic and the Republic of Slovakia. A fact that did not mitigate but worsened the relations between Hungary and Slovakia as part of the second's population was still of the Hungarian ethnic.

Again dots are connected and so we can understand the current border situation in Hungary and even more after the current refugees crisis. During the last year, the customs access control in the border become tougher. At some point, different modes of transports were not able to cross boundaries between Hungary and Croatia and Serbia. Intensifying the control emerges as the main obstacle for relations and connections to grow, for megacities to happen.

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[2] "The Visegrad Group (also known as the "Visegrad Four" or simply "V4") reflects the efforts of the countries of the Central European region to work together in a number of fields of common interest within the all-European integration. "(International Visegrad Fundation, 2016)

[3] "Warsaw Pact, formally Warsaw Treaty of Friendship, Cooperation, and Mutual Assistance, (May 14, 1955–July 1, 1991) treaty establishing a mutual-defense organization (Warsaw Treaty Organization) composed originally of the Soviet Union and Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania. " (The Editors of Encyclopædia Britannica, 2016)

[4] "European Free Trade Association (EFTA), group of four countries—Iceland, Liechtenstein, Norway, and Switzerland—organized to remove barriers to trade in industrial goods among themselves, but with each nation maintaining its own commercial policy toward countries outside the group." (The Editors of Encyclopædia Britannica, 2016)

[5] "North Atlantic Treaty Organization (NATO), military alliance established by the North Atlantic Treaty (also called the Washington Treaty) of April 4, 1949, which sought to create a counterweight to Soviet armies stationed in central and eastern Europe after World War II." (Haglund, 2016)

[6] The EEC, current European Comunity (EC), is the "former association designed to integrate the economies of Europe". (Gabel, 2016)

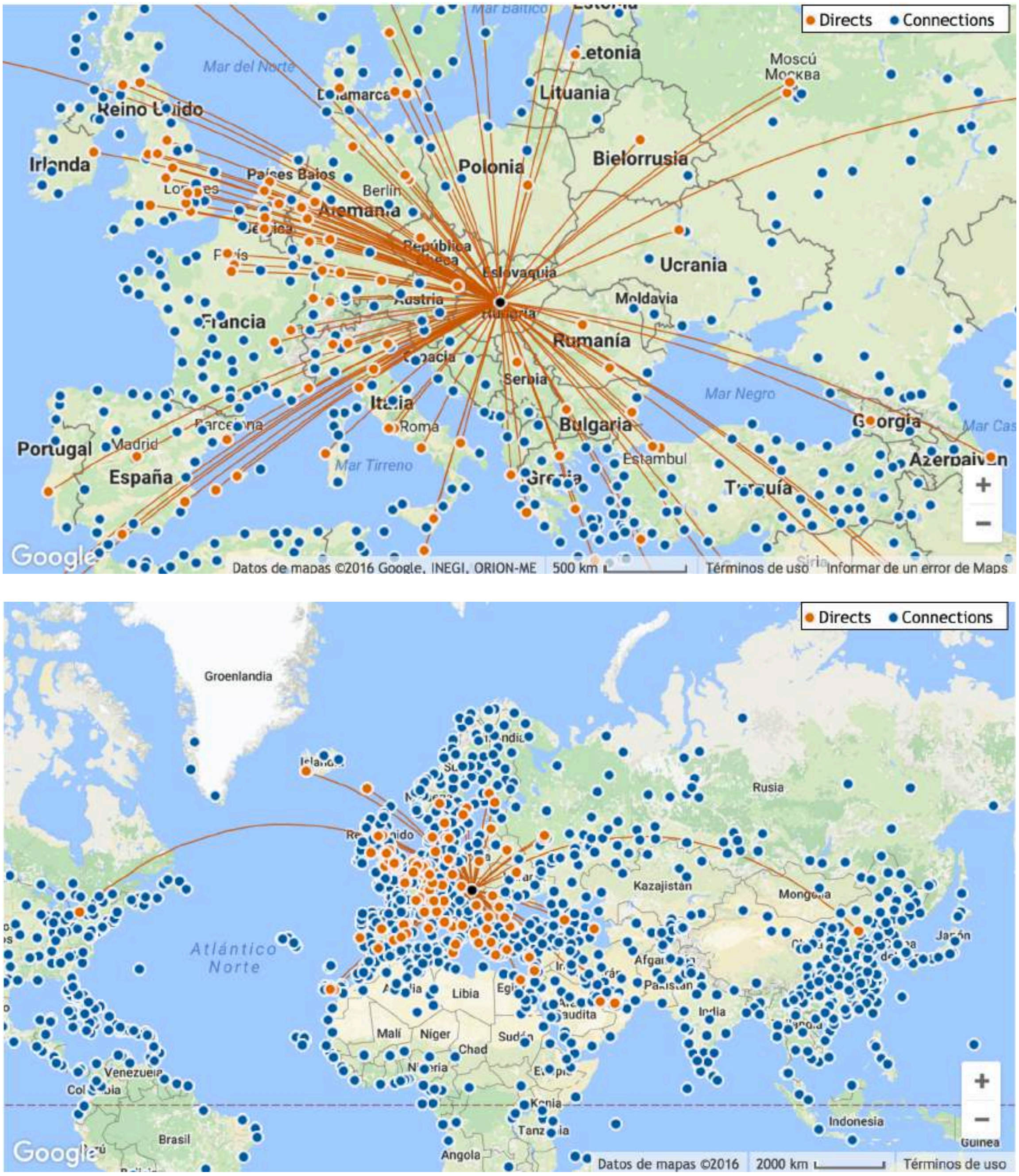

Fig. 1. *Destinations air-connected to Budapest*. Source **(Budapest Airport, 2016)**

The influence of Liszt Ferenc International Airport is understood as the centre of a virtual triangle gathering the Baltic, the Black and the Adriatic Seas (in a larger scale Fig.1). At a regional level, it is located in an advantageous geographical position as the Central-Hungarian region embodies the main economic power of Hungary and so does the Hungarian aviation market. However, it faces a growing challenge in the North-West as a result of the cooperation between the trendy airport of Vienna, exceeding the twenty million passengers per year (Airline Network News and Analysis, 2016), and Bratislava. In the North, Warsaw is introduced as the main airport surpassing the minimum limit of ten million passengers (Airline Network News and Analysis, 2016). Note that Budapest is a three and four hours far from Bratislava and Vienna, respectively, and it could even take ten hours to Warsaw. It's quite important to mention that both challengers, Vienna and Warsaw, hold a good an efficient access to the airport by different modes of transport.

Not exceeding the borders of Hungary, the "catchment area" of the International Airport of Budapest hosts the potential and, together with the impact of the current spreading of the European transportation network to the East and South, recognizes a feasible expansion towards regions like Transylvania, Vojvodina and Transcarpathia. It means leaning the main attention to the Southern and Eastern region of Hungary. That is why their economic interests may turn their focus on the Eastern market. Now this applies directly to the main airports of the multi-airport region that has been considered in this paper. Those are the International airports of Budapest, Vienna, Bratislava, Belgrade, Zagreb and Cluj-Napoca.

Back to the "airport network" concept, it is worth to highlight and set the scenario for further studies the possibilities of carrying out an internationally coordinated and optimized airport group with Vienna and Bratislava. Upgrading the relationship teaming up with both of them due to its proximity (less than 250 kilometers from each other) would mean a quantum leap stepping forward the forefront of the international air transportation. At the moment, the transfer traffic between these airports is negligible.

According to the 2015 official data (Airline Network News and Analysis, 2016), Liszt Ferenc International Airport managed over 10.298.63 million passengers, proving an increase of a 12,5% from 2014. The other "large" airport in the region hosting over ten million passengers per year, Vienna, escalated only around a 1,3%. Cluj-Napoca (25,8%) and Bratislava (15,9%) embodied the greatest advancements after launching new routes and improving the connections, respectively. Note that both of them total in less than one and a half million passengers so the increase in total values was similar to Budapest. Finally, Belgrade (3%) and Zagreb (-1,8%) stuck their increase as a result, probably, of the lack of low cost straight connections to other European targets.

Budapest ranked 49th considering the number of passengers . A great jump from the 53rd place back in 2014. Among the post communist countries, it is still 3rd after Prague and Warsaw (Airline Network News and Analysis, 2016). Some enterprises including the application of competitive prices to the parking or the implementation of some developments like better facilities and public transportation tickets due to an agreement with BKK[7], have been converted in such a forceful trend. Spot as well the importance of these initiatives after Malév Hungarian Airlines, the main Hungarian national airline, was declared insolvent and bankrupted back in 2012 (Wachman, 2012). It was transcribed as a one and a half million transfer passengers cut that year but Budapest recovered quickly empowering the so-repeated origin-destination model.

However, the Terminal's 2 capacity of the International Airport of Budapest is limited in eleven million passengers (Város-Teampannon Ltd , 2014). Numbers about to be reached.

[7] Budapesti Közlekedési Központ (Centre for Budapest Transport) (Budapesti Közlekedési Központ (BKK), 2014)

This is why, not far from now, a reopening of the Terminal 1 would happen to increase in two and a half million passengers the current capacity. Moreover and until no further developments connecting the interurban railway network to the Terminal 2, it's worth to consider that the Terminal 1 it's actually linked and it would directly improve the accessibility to the airport.

The fact that the current busted Terminal 1 is railway-connected but the active terminal is not, sets the scene to have a better look into the current modes of routing to the Liszt Ferenc International Airport. As it is indicated, there is no interurban railway connection and the access from the city center of Budapest requires, at least, of two modes of transport because there is no straight link. A part of increasing the trip time to the airport, it may impact negatively the reliability of the network. The more modes of transport used, the more waiting time and the more chances that the unpredictable can happen. Consider as well the quality service factor. The underground line M3 and the 200E buses that bring together the city and the airport, are not close to being new-branded. Moreover, as Budapest is a city with extreme weather conditions, it can be determinant for an uncomfortable journey to the airport. This factor is decisive when choosing the mode of transport and helps prevail the private transport. However, the road connection has been impressively improved after completing the southern and eastern segment of the M0 ringroad. This holds either for East and West respectively for North Hungary due to the existing system of radial highways and motorways (M1, M2, M3, M31, M5, M6, M7) (Város-Teampannon Ltd , 2014).

The main issue to solve those accessibility obstacles lies in the government's approach. Developing the economy and settling its hub status in the Carpathian Basin would be major achievements if it is recognized the importance of investing and improving the macro-regional transport connections. All together may change its current "low cost base" status earned as a result of being home to a dynamically growing low cost company like Wizz Air. Moreover, low cost airlines add more than half the total traffic.

Some other challenges currently faced by the International Airport of Budapest embrace the continuous decline of European Union's funds in the period 2014-2020 (Város-Teampannon Ltd , 2014), the lack of stability in the ownership condition of the airport, the yet to be defined catchment area and the mostly virgin environment (economically speaking) along the access route to the airport.

3. OBJECTIVES AND METHODOLOGY

The aim of this paper lies in improving the accessibility at airports from an air passengers flow standpoint, applied to Budapest. In order to do so, understanding the region is determinant. Comprehending the historical roots and the international clashes that have shaped the current situation and can help us decide where to move forward in this paper. From this perspective, the topics to cover are; which are the most important variables of the passengers' airport choice, the evaluation the statistical model approach and how these results can be used to analyze airport competition in a multi-airport context.

With the available data, a direct aggregated abstract modeling approach will lead the study, fostering a macro-regional scene and leaving it for a further study focused on a micro-regional picture. The model, first of all will be proven valid for the current configuration. Afterwards, will be used to aggregately predict the impact of several scenarios in the airport of Budapest. All together used to understand which changes should be applied in the current system towards enhancing Budapest as the real deal in the Center-East of Europe, starting by gaining some importance in the air transportation network.

The scenarios considered in the present paper are; improving the interurban bus network and the interurban railway network from the cities totaling in more than 100.000 population and from the regional cities of Hungary to the airport of Budapest, improving the accessibility to the airport from the city center of Budapest as a point of view of the public transportation facilities, the previous three together, doubling the current interurban bus network and interurban railway network from and to Budapest, the suppression of wasted time in borders and the not-so-hypothetical and probably situation in the years to come of Hungary yielding the Euro in detriment of the Forint.

4. REVIEW OF THE STATE OF THE ART

4.1. Literature review on distrcrete choce models

The election between two modes of transport cannot be analyzed as a simple goods election. Every consumption decision, in general, assumes that time is bound to the consumption. Disregarding that time is just an attribute of a given good, it is to be a variable itself to be considered as equal as the good is.

It is necessary to acknowledge that the election of a mode of transport is just one of the characters that interact in the transportation demand. The willingness to start a journey comes from the answers to a set of questions, which should be ordered logically. In some circumstances, the destination election, the mode, the schedule responds to a pre-established sequence. In some others, the destination and the mode are only considered.

Furthermore and as remarked above, air passengers have to choose not only the airport but also the airline as well. Those choices are made based the "Level of Service" specified previously. Deepening on the parameters that are to be considered in this paper, Ashford and Benchemam (1987) model the passenger's choice of an airport in central England in the late seventies. They suggest that the main indicators that affect passenger's choice are the travel time to the airport, the fare and the frequency of the service. Among them, it is noted that the importance of each of them varies upon the type of passenger; fare is dominant for leisure time travelers and travel time for business travelers. Furthermore, Thompson and Caves (1993) introduce the number of seats available as another important variable. Seats and frequency are strongly related though. Caves et al. (1991) concludes that "the hypothesis that frequency is an airport variable when considering the competition between an emerging and a mature airport cannot be rejected".

As a consequence of all the previous suggestions, more and more precise modeling approaches emerge in order to evaluate the air passengers demand. Let's briefly introduce some possible models, including the one developed in the present paper highlighting its applicability in understanding the geography of the air transportation, so we can better understand why this model has been chosen.

Generally, there are two ways to categorize the transportation demand forecast modeling; the statistic and the explicative models (Shmueli, 2011). The first one is based on a defined statistical relation whose coefficients are obtained from the correlation of the observed data for the current situation. This model, finds its main inconvenient in rejecting any kind of forward thinking about the evolution of the users behavior. Statistical relations' aim is not to reproduce them and the coefficients cannot provide any further significant information in most of the cases. Unfortunately, this approach can lead to not-so-reliable results. The second one, the explicative models, use a detailed data analysis to foster a mathematical answer to the system's behavior. The parameters, adjusted to the current data, now have a meaning and can help better predicting and modeling future scenarios.

Depending on the level of aggregation under which the economic parameters' behaviors are taken into account, the standardizing model can be split in; aggregated and disincorporated models (UPCCommons). The first one is intrinsically linked to macro-economic models and studies the election of the mode of transport through the volume or part of the volume of the observed traffic in a given region. It permits to have a first approach of analyzing regional movements origin-destination without considering particularities of the passenger inside each and every zone. Consequently, their characteristics are represented as a population itself. On the contrary, the disincorporated models refer to micro-economic models focusing on individual behaviors. Their purpose is to explain in a probabilistic way, the election behavioral trend of the passengers linked to random phenomenon.

Finally, the way of choosing among the several modes of transport is determinant as well. The sequential models consider a set of different elections made by the passenger. And so each and every step in the chain is considered particularly and independently from the others. This model calculates firstly the global traffic for every mode, before introducing changes in the system. The direct models (UPCCommons), on the other hand, consider the set of decision as one. Consequently, they lead to only the calculation of the mode's traffic and can depict the global traffic as the sum of the particular traffics for each and every existing mode of transport in the system.

There are some tangible limitations that have prevented further and more precise studies in the matter. The region considers eight different countries (the whole Hungary, the South-West of Ukraine, the West of Romania, the North of Serbia, the North-East of Croatia, the North-East of Slovenia, the East of Austria and the South of Slovakia), filled by more than sixty million people. It means that the modeling approach can even be different for each region. Parameters have to be calibrated differently. As it was mentioned before, GDP per capita, population size, people's preferences, etc. vary upon a small given region with different cities. What if this large region is considered? Any disincorporated or sequential approaches should be delimited by an smaller area of influence. Even more concerning, the hard access to feasible and useful data has been determinant in leaning the paper's approach towards a direct aggregated model.

The first aggregated transportation models as introduced earlier, refer to Newton's gravity model. Its simplest expression assumes that the traffic is proportional to the population of the origin and destination and inversely proportional to the square geographical distance among them. It served as a first grasp of the concept attractiveness between two places. Later on, deeper studies have brought into question the behavior of those parameters, translating them to a general equation where exponents have to be calibrated with empirical data. Furthermore, some other models include new variables trying to answer precisely how the attractiveness can be spotted and how the opposing factor; the former geographical distance, can be modeled.

Whichever the model is considered, some requirements are to be fulfilled (UPCCommons); the total amount of traffic must be the sum of the traffic of all the existing modes, the total and modal demand function are continuous, a mode of transport whose frequency is poor happens to have a very few influence on the total demand and its share, if the price or the time of a mode decreases (despite increasing the frequency) the total demand cannot decrease nor the other modes' demand increase and the demand depends only on the characteristics of the modes of transport and of its level of service.

The notion of abstract model emerges after the intention of designing models capable of adapting new modes of transport in the system as a matter of the technological development. In that sense, the Quand-Baumol (Vickerman, 1975) do not differentiate the modes of transport by its name. Instead, they do it by its benefits. If so, the focus is set on the level of service perceived by the passenger, no matter the character of the infrastructure. So, the likeliness to choosing a mode is linked to the comfort, the speed, the fare, the time, the security, the reliability, the frequency, etc. Mark that as an aggregated abstract approach it simplifies the study and adapts perfectly the any change in the system regarding and implementation of a new mode of transport if they both can be reduced to the characteristics mentioned.

It is mandatory to comment that now the parameters prepared are not only absolute but relative. It means that, for example, the fare of a mode of transport is not determinant by itself but also by its relation with the rest of fares of the modes of transport. The advantages of this model comprise predicting the effect of the introduction of a new mode on the existing modes, that this new mode can be easily understood in the system by its characteristics and that the total demand is a function of all the possible variables and capable of measuring the inducted traffic from the existence of the new mode.

Despite being argued that it does not really happen that the passenger has no preference upon a mode of transport, this model has been chosen in the present paper as it can solve simultaneously two problems; the generation and the share of traffic.

In order to shape the used function that models the traffic in the present paper, it was firstly considered the following parameters; the population size and the GDP per capita in both origin and destination, the fare and relative fare, the time and relative time, the total amount of direct commercial flights in each mode of transport as its relative relation with the others' amount and the total modes of transport, were enough to represent it. To put that in practice, six airports (serving as the departing airport) and a total amount of twenty-three destination airports were studied. Those six airports refer to the cities of Budapest, Vienna, Bratislava, Belgrade, Zagreb and Cluj-Napoca. Regarding to the destinations, some of the airports that handle yearly the largest amounts of traffic were studied. Those refer London Heathrow Airport, Barcelona Aeroport del Prat, Amsterdam Schiphol, Madrid Barajas, Berlin Tegel Airport, Paris Charles de Gaulle, etc,

As long as the "catchment area" of each airport is not strictly defined to associate the population size of the eligible passengers to take part in the journey, the socioeconomic parameters chosen where linked to the metropolitan area, the population size and the GDP per capita. As for the fare and time, both the cheapest and the shortest route between each and every pair of combinations was stored.

The research was made twice for two different periods of time and for every day of the week, so it was possible to have a weighed average of both parameters. Finally, eurostat (European Comission, 2015) provided the necessary traffic data between most of the origin-destination pairs and so did for the amount of direct commercial flights. Note that it is just considered the travel time in the vehicle as a way of simplifying results. The perception of the amount and the "wasted" time lost in an airport is subjective, particular for every airport and also can be different any given day. That is why it was decided not to consider this variable. The three modeling functions considered to adjust better traffic are the ones that follow:

$$T_{ijk} = \alpha_0 P_i^{\alpha_1} P_j^{\alpha_2} Y_i^{\alpha_3} Y_j^{\alpha_4} H_k^{\alpha_5} H_{ijk}^{\alpha_6} C_k^{\alpha_7} C_{ijk}^{\alpha_8} D_k^{\alpha_9} D_{ijk}^{\alpha_{10}} N_{ij}^{\alpha_{11}} \quad \text{(Eq. 1)}$$

$$T_{ijk} = \alpha_0 P_i^{\alpha_1} Y_i^{\alpha_2} H_k^{\alpha_3} H_{ijk}^{\alpha_4} C_k^{\alpha_5} C_{ijk}^{\alpha_6} D_k^{\alpha_7} N_{ij}^{\alpha_8} \quad \text{(Eq. 2)}$$

$$T_{ijk} = \alpha_0 H_k^{\alpha_1} H_{ijk}^{\alpha_2} C_k^{\alpha_3} C_{ijk}^{\alpha_4} D_k^{\alpha_5} N_{ij}^{\alpha_6} \quad \text{(Eq. 3)}$$

Where P and Y are the population and the GDP per capita in the origin i and the destination j, respectively. N refers to the amount of modes of transport the passenger is capable of using to get to the destination. H, C, D represent the shortest time, the cheapest fare and the total of direct commercial flights for the given mode of transport. Finally, aim to represent the relation between the last parameters with the cheapest fare, shortest time and the most commercial direct flight connections of all the possible modes for the given origin and destination pair. Those variables are relative. The correlation of the function and the calibration of the parameters obtained for the first of them is summarized in the table 1.

The present results consider the research of air traffic data, as it was stressed before, between the six airports studied in the paper and twenty-three destination airports. Those are, AGP, AMS, ARN, BCN, BRU, BVA, CDG, CRL, CPH, DUB, DUS, FCO, LGW, LHR, LIS, LTN, MAD, MUC, MXP, PMI, STN and TXL. Note that all the data related to those connections is attached in the annex. Both the populations (X1, X3) and GDP per capita (X2,X4) in the origin and destination, the mode's cheapest fare (X5), the relative fare (X6), the mode's fastest time (X7), the relative time (X8), the amount of straight connections (X9), the relative amount of connections (X10) and the number of modes (X11) are considered in this option.

The correlation coefficient approves the accuracy of the traffic volume modeling. However, the high probability (way over 0,05) of the origin population and GDP per capita may be a concern while destination parameters seem to be quite more related to the prediction of the traffic. Note that the GDP per capita in the destination (X4) has a negative impact in the likeliness to fly there from one of the origins. It is also worth to mention that, under this scenario, increasing the amount of modes of the system has a positive, low but positive impact of the traffic. Bear in mind that this function is to be reproduced for each and every pair of origin and destination. Then, the partial traffic would be increased if an extra mode was added and relative time and fare stayed the same.

Regression statistics				
Correlation coefficient			0,985647862	
determination coefficient			0,971501708	
Adjusted			0,965104132	
Standard error			0,068682263	
Observations			61	
	Degree of freedom	**Sum of squares**	**Average square**	**F**
Regression	11	7,879705736	0,716336885	151,8546606
Residuals	49	0,231145407	0,004717253	
Total	60	8,110851144		
	Coefficients	**Standard error**	**t-statistic**	**Probability**
Interception	2,092365445	3,152052752	0,663810415	0,509923103
Variable X 1	0,01946703	0,033662589	0,578298654	0,565711059
Variable X 2	0,300261954	0,757551758	0,396358336	0,693561547
Variable X 3	0,0243209	0,030363531	0,800990513	0,427004114
Variable X 4	-0,275532768	0,118418351	-2,326774244	0,024154895
Variable X 5	-0,310278388	0,078453618	-3,954927717	0,000246298
Variable X 6	-0,061440123	0,084062927	-0,730882505	0,468331545
Variable X 7	0,268423383	0,086693115	3,096247996	0,003238158
Variable X 8	-0,231664552	0,093885777	-2,467514881	0,017146263
Variable X 9	0,912645469	0,055072108	16,57182727	1,00584E-21
Variable X 10	0,00814331	0,018732903	0,434706257	0,665684163
Variable X 11	0,10922371	0,098359071	1,110458942	0,272220982

Table 1. *Regression statistics based on Eq. 1.*

However, when studying the traffic both ways it does not make a lot of sense. Lastly, it suggests that an increase in the travel time may have a positive impact in the generation of air passengers, and that's something doubtful at least. The reason why this happened is because different traffics were considered from different origin and destination airports. It means that, for example, we are approaching the problem the same way for a Budapest-Lisbon connection (averaging 285 minutes) and for a Vienna-Munich connection (averaging sixty minutes). In that sense, two direct straight flights are compared with a huge duration difference. And that difference is not a consequence of a stopover nor gives us any clue about the traffic generated.

It is hard to conclude anything by mixing origin and destination airports. Eq. 3 is applied to data referring to the same origin and destination cities. However, in order to caliber such function it is necessary to have access either to the historical traffic between airports or replying air fares and times to previous years, and that's unavailable data.

Despite the limitations, Eq. 2 fosters to be a better model by disregarding the destination parameters and the relative amount of total direct connections, the quite small coefficient of which suggests its irrelevance in the study. The correlation of the function and the calibration of the parameters obtained for the second of them is the following in the table 2.

Regression statistics				
Correlation coefficient			0,982584854	
determination coefficient			0,965472995	
Adjusted			0,960161148	
Standard error			0,073385625	
Observations			61	
	Degree of freedom	Sum of squares	Average square	F
Regression	8	7,830807745	0,978850968	181,7584364
Residuals	52	0,280043399	0,00538545	
Total	60	8,110851144		
	Coefficients	Standard error	t-statistic	Probability
Interception	1,917151123	0,37100598	5,167439957	3,82359E-06
Variable X 1	0,01566593	0,039575085	0,395853354	0,693832765
Variable X 2	0,032427917	0,044628306	0,72662218	0,470715859
Variable X 3	-0,204816576	0,07367321	-2,780068578	0,007548809
Variable X 4	-0,138296612	0,084160447	-1,643249488	0,106365199
Variable X 5	-0,242692113	0,074985263	-3,236530781	0,002107606
Variable X 6	-0,126139193	0,089386342	-1,41116853	0,164150215
Variable X 7	0,940893549	0,043561122	21,59938723	1,24679E-27
Variable X 8	0,022794685	0,100172464	0,227554395	0,820885024

Table 2. *Regression statistics based on Eq. 2*

These results are obtained from calibrating the traffic with the equation (2). The data considered is the same as the previous scenario, six origin and twenty-two destination airports. However, the population and GDP per capita at destination and the relative amount of direct commercial flights aren't studied. The results prove to be better than the last approach. The correlation is still accurate and the standard error quite low. The parameter associated to the time (X5) has now the right sign. As it is observed, traffic is more sensitive to changes in time rather than the fare. Moreover, the p-value proves how closely related are the traffic and the amount of straight commercial flights (X7). The population and GDP per capita at the origin (X1,X2) and the number of modes (X8) seem to be less determinant. They are still considered as it believed that it is due to the lack of sufficient data to caliber the values properly instead of actually being non-relevant. The limitations in the present scenario are the same we have seen in the previous. The only different with the last is that disregarding three variables, the function obtained has a better adjustment.

However, it is desired to be checked a third case in which socio-economic parameters do not matter and where origin and destination are fixed for all the due data. So, in order to contrast the validity of the Eq. 2, it is studied in a different scenario with a different modeling function shown in table 3. In that case, Barcelona and London are considered as both the origin-destination pair. The aim of pairing these cities lies in having just one airport in Barcelona and several in London with current traffic information for this route (LGW, LHR, LTN, SEN). So if a journey takes longer it might be strongly related to a delay or a stopover, decreasing the chances of a high volume of traffic in the due mode. Same procedure, the research is conducted on the cheapest fare and fastest flight between the mentioned cities and for every pair of airports, for the seven days of a week and for every month of the year, so the average results can be weighed.

Furthermore, it is to be proven how the model reacts without considering the population nor the GDP per capita in both origin and destination. That is the main limitation of the present option. We find ourselves in dual thread; if It only applies to the present, population and GDP per capita remain constant, being redundant parameters in the correlation with obtained coefficients equals to 0. Otherwise, if we want to take them into account, we need to consider past values. Going back to the equation considered in the present scenario, it means that fares and times cannot be truly introduced in the system. If so, there are some studies that suggest how air fares have changed in the recent years. Yet they are not specific for that particular connection and may not guarantee a reliable approach. And that is even more concerning when time of past connections cannot be adjusted.

Regression statistics				
Correlation coefficient			0,997516951	
determination coefficient			0,995040068	
Adjusted			0,994801991	
Standard error			0,030537357	
Observations			132	
	Degree of freedom	Sum of squares	Average square	F
Regression	6	23,38502096	3,897503494	4179,493216
Residuals	125	0,116566271	0,00093253	
Total	131	23,50158723		
	Coefficients	Standard error	t-statistic	Probability
Interception	5,161879597	1,363470158	3,785839805	0,000236654
Variable X 1	0,051058143	0,03126234	1,633215651	0,10494005
Variable X 2	-0,077145845	0,033794112	-2,2828191	0,024130197
Variable X 3	-1,468605682	0,626293091	-2,344917583	0,020606988
Variable X 4	1,560754514	0,625914455	2,493558826	0,013953568
Variable X 5	1,03375459	0,009306284	111,0813511	8,5686E-127
Variable X 6	-0,14714168	0,053000489	-2,776232497	0,006345491

Table 3. *Regression statistics based on Eq. 3*

In relation to the resulting coefficients, in spite of the highly accurate correlation coefficient, This scenario still was considered to emphasize the complexity of the calibration of the function and to prove that the equation (2) can more than fairly predict and render the air passenger's flow. Mention that the system proves to be more sensible to time changes rather than price changes. It could be true as we are considering an aggregated population with both, business and economy profile passengers. However, mixing positive and negative signs for fare and time parameters finally leads us to distrust the results.

4.2. Literature review on Graphs Theory and Dijkstra's Algorithm

From that point and once modeled the air passenger's traffic function, the focus needs to be addressed to the characteristics every mode has to offer. In the prompt paper, as it was mentioned before, traffic is considered from all the cities in the region totaling more than 25.000 inhabitants to all of the chosen European destinations. In order to do so, the current road, bus and railway network is translated into the system as connections bringing the cities together, the nodes. Then, every mode is distinguished depending on the airport used on the way to the destination. There will be a maximum of six possible modes for a given destination and the global characteristics of them are based on the particular situation of every connection in the mesh. The traffic modeling is to be replied for each and every possible origin-destination pair, so the total demand and the consequent share can be obtained.

This approach of connecting the origin with the departing airport requires a closer look into graphs theory and the algorithm that fits better to solve our problem. A graph is a set of elements called nodes or vertices and its relations based on connections. It can depict the different communication possibilities between two points of the system. To do so, it is necessary to distinguish among some topological requirements; orientation and connectivity.

Graphs can either be oriented or non-oriented (Department of Mathematics and Computer Science, Balearic Islands University) as a result of the character of the system's connections. If the order of every vertices or nodes is considered, the graph is non-oriented. It basically assumes that between two specific nodes there is just a possible way of moving forward. On the other hand, detailing the double relation existing between two nodes we are defining an oriented graph. Note that an oriented graph comprises the possibility of relating a pair of nodes both ways but not necessarily every pair of nodes needs to hold both relations.

Now thinking in the system as a whole and not in every node's relations, the connectivity is the property to be aware of. The amount of connections wraps the two possible categorizations. A graph is connected, regardless of the orientation, if there is at least an existing cycle between all the pair of nodes. On the other hand, if connectivity is so heavy that the system holds at least one straight connection for every pair of nodes, we will say that the graph is strongly connected (Department of Mathematics and Computer Science, Balearic Islands University).

Applying this concept to the transportation network and to the present paper, a non-oriented and connected graph will be the approach considered to better reproduce the air passenger's flow through the network upon the current conditions and as a result of introducing changes. The transportation network has to ensure; that the origin and destination nodes have no further connections, that in a given node (not an origin or destination) the arriving flow must be equal to the departing flow and finally, that the sum of all the flows departing from any node must equal to the sum of all the flows arriving to any node, the total flow of the system.

Furthermore, with the due data it is possible to constraint the maximum flow possible in every connection and to consider congestions in the system, obtaining the real maximum and minimum flow. Applying different costs to every connection, fare and time in the present paper, it is feasible to determine the minimum fare critical path and the minimum time critical path. It will be applied to our system in order to obtain the fastest and the cheapest way from all the origins to the six airports proposed. Note that both, fare and time connections, will be considered as two separated systems leading to the possibility of having two different optimal routes between origin and destination.

The point now is finding the critical path for both price and time for all the possible origin-destination pairs. This problem can be reduced to finding the set of arcs that connect all the nodes inside the graph system so the minimum sum of the associated values can be obtained and the research of the shortest path. As the origin and destination points are well determined in every case, it is enough just finding the shortest path. So, the length of the connection is the sum of the weights of its constituent edges and the distance between two given nodes is the length of the minimum length path if there is a path that connects them, otherwise is infinite.

Dijkstra's algorithm (Yan, 2014) reproduces in a very simple way an easy solution to the suggested problem. It constructs the shortest path tree edge by edge; adding one new edge each step as it increases the distance from the source vertex. Note the simple code used to understand better its functioning.

```
V=[];
k=0;
i=0;
j=0;
for k=1:108
    for i=1:108
        for j=1:108
            if V(i, k) + V(k, j) < V(i, j)
                V(i, j) = V(i, k) + V(k, j);
            else
                V(i, j) = V(i, j);
            end
        end
    end
end
V
```

Fig.2. *Dijkstra's Algorithm Matlab code*

It basically reproduces for every node to every node the process. Evaluates the connection between the node i to j through a third intermediate node k. If the distance between i and j is greater than the sum of distances between i and k and k and j, now this sum would be the length of the new path i to j. This is also called relaxation. It finds as well new paths from non-existing connections. Note that V is the either the cost or time matrix and it is applied from one to 108, the dimension of the matrix.

An other challenging issue that can provide some useful insight information is determining the maximum allowable flow in the system. Due to the heterogeneity of the connections of the present problem, the difficulty of translating them into that matter and proven the good results obtained, this chapter is left for further and future studies

It is worth to mention that, as it was previously stressed, only the properties of the mode are considered and, as long as the region deals with different populations of different countries, it was decided not to assume a fixed value of time that could be integrated in an utility function. Oppositely, the modeling function asks for the minimum fare and fastest time for a pair of nodes. Then, it is to be considered that the fastest time between the two is the fastest route no matter the cost is and the cheapest fare is the less expensive regardless of the time spent in the journey. Both values are obtained from the application of the Dijkstra's algorithm to the graph system and later introduced in the direct aggregated abstract modeling function.

5. APPLICATION OF THE MODEL: BASE SCENARIO

The region studied in the present paper gathers eight countries; Hungary, Southern Slovakia, Southern-Western Ukraine, Western Romania, Northern Serbia, North and North-Eastern Croatia, North-Eastern Slovenia and Eastern Austria. 102 cities totaling more than 25000 inhabitants and the six airports are considered as the nodes that structure our network (Fig 3). Hence, the connections between all of them are particularized.

The delimitation of the region is stressed in light Brown and the main airports can be identified thanks to a greater letter size. Countries boundaries are highlighted in dark but the internal administrative regions structure is not specified:

Fig.3. *Studied region containing Hungary and some administrative regions of Romania, Serbia, Croatia, Slovenia, Slovakia, Austria, and Ukraine.*

Those need to be differentiated among over 100.000 population and the rest:

City	Region	Country
Budapest	Central Hungary	Hungary
Vienna	Vienna	Austria
Belgrade	Belgrade	Serbia
Zagreb	Croatia Proper	Croatia
Bratislava	Bratislava	Slovakia
Cluj - Napoca	Nord-Vest	Romania
Timișoara	Vest	Romania
Novi Sad	Vojvodina	Serbia
Graz	Styria	Austria
Miskolc	Northern Hungary	Hungary
Košice	Košice	Slovakia
Ivano-Frankivsk	Ivano-Frankivsk Oblast	Ukraine
Debrecen	Northern Great Plain	Hungary
Oradea	Nord-Vest	Romania
Szeged	Southern Great Plain	Hungary
Arad	Vest	Romania
Pécs	Southern Transdanubia	Hungary
Győr	Western Transdanubia	Hungary
Baia Mare	Nord-Vest	Romania
Nyíregyháza	Northern Great Plain	Hungary
Kecskemét	Southern Great Plain	Hungary
Osijek	Slavonia	Croatia
Subotica	Vojvodina	Serbia
Satu Mare	Nord-Vest	Romania
Székesfehérvár	Central Transdanubia	Hungary

Table 4. *Cities in the region with over 100.000 people* **(Multiple demographic institute sources)**

Shortly after the previous ones, we find all those cities with few less population; Maribor, Mukacheve, Nitra, Banská Bystrica, Szombathely, Zrenjanin, Pančevo, Bistrița, Szolnok, Reșița, Trnava, Kalush, Tatabánya, Velika Gorica, Békéscsaba, Kolomyia, Zalaegerszeg, Sopron, Deva, Veszprém, Hunedoara, Slavonski Brod, Zalău, Eger, Sankt Pölten, Nagykanizsa, Dunaújváros, Turda, Sisak, Sombor, Varaždin, Hódmezővásárhely, Wiener Neustadt, Zvolen, Nové Zámky, Bjelovar, Lugoj, Michalovce, Spišská Nová Ves, Cegléd, Kikinda, Sremska Mitrovica, Baja, Sighetu Marmației, Samobor, Salgótarján, Petroșani, Komárno, Vršac, Levice, Ózd, Vinkovci, Szekszárd, Gyöngyös, Dej, Mosonmagyaróvár, Pápa, Hajdúböszörmény, Gyula, Ajka, Koprivnica, Kiskunfélegyháza, Ruma, Piešťany, Szentes, Topoľčany, Khust, Esztergom, Bačka Palanka, Vukovar, Lučenec, Borșa, Klosterneuburg, Indjija, Baden bei, Wien, Zaprešić and Uzhhorod.

Finally, it is worth to show the difference in population and GDP per capita among the different administrative regions so it can help us understand future scenarios results. Data from the Institute of Demographics in each case. The mentioned data follows:

Administrative region	Population	GDP per capita (euros)
Central Hungary	3.342.006	35.710
Vienna	2.600.000	53.360
Belgrade	1.659.440	10.086
Croatia Proper	1.085.288	7.062
Bratislava	659.578	51.200
Nord-Vest	1.111.695	13.100
Vest	750.804	15.800
Vojvodina	779.736	5.774
Styria	273.838	38.746
Northern Hungary	424.865	13.306
Košice	318.819	16.500
Ivano-Frankivsk Oblast	348.250	2.700
Northern Great Plain	429.666	14.172
Southern Great Plain	511.375	15.046
Southern Transdanubia	182.576	15.048
Western Transdanubia	414.705	22.346
Slavonia	230.682	8.271
Central Transdanubia	369.434	19.586
Podravska	94.809	17.900
Zakarpattia Oblast	126.256	2.132
Nitra	226.884	18.200
Banská Bystrica	151.526	15.100
Trnava	98.126	23.400
Lower Austria	147.529	35.158

Table 5. *Administrative region, Population and GDP per capita (euros)* **(Multiple demographic institute sources)**

On the one hand, note that the population considered refers to the metropolitan area, if there is one. On the other, the GDP per capita is not individualized to any population or metropolitan area, but to the administrative regions that subdivide the whole region. Therefore, all the cities comprised in a given administrative region are considered to have the same GDP per capita.

In relation to the connections, it is necessary to split them in three different scenarios for a better understanding of their relations. Those are the connections between the origin and the departing airport, the connection between departing and arriving airports and, finally, the link between arriving airports and the final destination. Connections are translated into the system as time values and fare values, the chosen characteristics. However, waiting and transfer times in the nodes are not considered. Depending on each and every possible route, the waiting and transfer times can be ones or others. Moreover, since schedules are not put in the system, it is decided not to count on those variables.

The characteristics (price and time) of the connections between the origins and the departing airports are studied individually. Independent grids of road, railway and bus are introduced in the network to later simplify them if necessary. Regarding to road connections and as a matter of homogenizing the output, it is considered that the passenger is driven to the destination in a two people full car. Hence, the price and time related to the road connection refers to both ways, as far as we assume the driver has to make it back. Moreover, as we considered price and time as completely independent variables, the fare of a road connection excludes any economic value of time. To monetize it, the road haulage charges and taxes, euros/km (Organisation for Economic Co-operation and Development, 2014) were applied. Note that this data was not available for Serbia, Croatia and Ukraine, as countries not included in the European Union. Nonetheless, a regression relating the net charge per kilometer with the average price of car and the euro/litre price for some European countries ensured the obtainment of these lacking data table 6. The current net charge per kilometer is the following:

Country	Austria	Hungary	Romania	Croatia	Serbia	Ukraine	Slovakia	Slovenia
Euro/km	0,32	0,14	0,11	0,15	0,12	0,09	0,24	0,23

Table 6. *Euro/km road haulage* **(Organisation for Economic Co-operation and Development, 2014)**

Bus and railway connections are studied individually as well, mainly targeting the next running bus companies; Orange Ways (Orange Ways, 2016) in Hungary and Romania mainly, Student Agency (Student Agency k.s., 2016) in Slovakia, Flix Bus (FlixBus, 2016) in Croatia and Austria mostly, Eurolines (VOLÁNBUSZ Transport Company Ltd, 2016) for domestic Hungarian connections and Fudeks (Fudeks Company Ltd., 2016) in the balkan countries mainly, and interurban railway companies; Mavstart (MÁV-START Vasúti Személyszállító Zrt, 2016) as the main operator in the region running from and to Hungary and the Railjet high-speed train (Deutsche Bahn AG, 2016) dominating the North-Western region.

As a matter of city to airport connection, it is worth to highlight the links between the six airports and their six main cities inside their area of influence as it is to be treated in Scenario C applying to Budapest. Most of them have decent connections to the airport. Budapest, with a weighed average of thirty-seven minutes is the one that takes longer. Bratislava and it's almost twenty minutes rank as the shortest. The cheapest average, however, goes to Cluj – Napoca as it is less than two euros per trip. Mark that the airport is close to Cluj – Napoca, the economy suggests quite low prices and that the net charge per kilometer as for the road connection is lower than the other airports. On the other hand, the most expensive access to the airport goes to Vienna with over twenty euros. Again, note that a weighed average obtained from the traffic function is assumed. There is no particular differentiation among the passenger's profile. So, it does not prevent anyone to get to Vienna's airport from the city of Vienna for less than twenty euros. Further information is gathered in the annex where fares, time and modal share can be all extracted (ANNEX 0; Departing airport – Arriving airport data).

This first city-airport connection is shown in the next two images (3 and 4 for both the fare and time "catchment area". It refers, separately, to the population that has a cheapest and fastest access to each airport but it does not mean flying from that airport. The connections departing airport to arriving airport and arriving airport to destination have not been considered yet and if so, it would be necessary to particularize for a given destination.

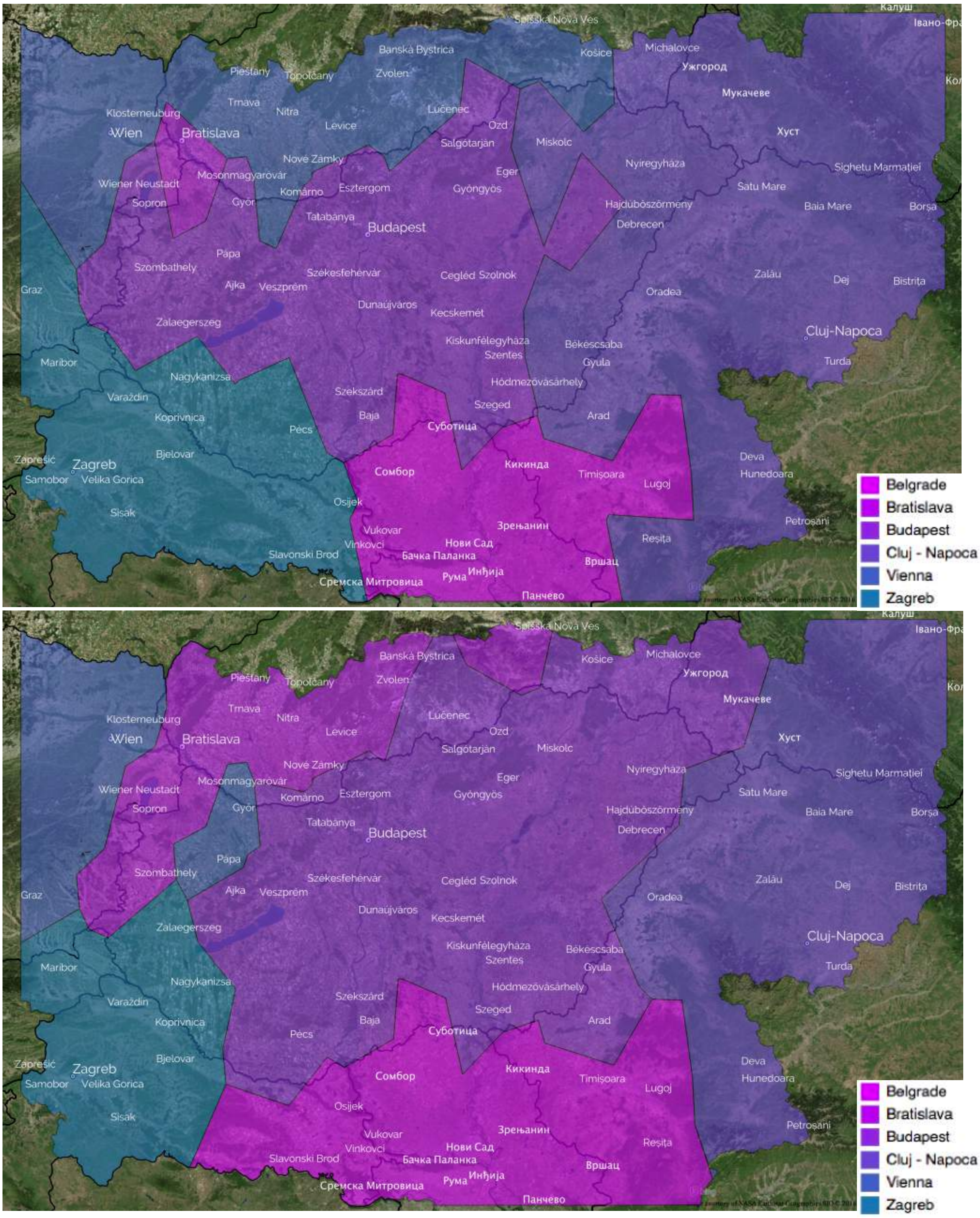

Fig.4 and Fig. 5. *"Catchment area" related to the fare and time access to the airport; Base Scenario*

In addition to that, a survey (table 7) was conducted to better understand the current situation of the connection Budapest to Liszt Ferenc International Airport. 151 people answered regarding how to get from the airport to city during the day and at night and vice versa. The results suggest that most of the people use the public transportation during the day but are more keen on using the private transportation at night. Moreover, reaching to too many (probably) International students can be an issue as the "car option" is instantly disregarded.

Mode of transport	City -> Airport		Airport -> City		Average fare (euros)	Average time (hours)
	Day	Night	Day	Night		
Taxi	14,67%	34,30%	14,57%	36,72%	22,22	0:31:17
Uber	10,00%	12,79%	6,62%	13,56%	12,2	0:31:17
Car	12,67%	13,95%	14,57%	13,56%	6,1	0:28:47
Shuttle Bus	12,67%	4,07%	5,30%	2,26%	13,93	0:35:30
Public transportation	58,67%	34,88%	58,94%	33,90%	1,68	0:57:25

Table 7. *Modal share in Budapest to Liszt Ferenc International Airport connection*

Departing and arriving airports are studied as well so to obtain an average minimum fare and fastest time uniting every of the six origin airports with the twenty-two destination airports. In order to do that, flights are researched for three weeks of three different months, so we can estimated a true and weighed average. In every situation just the fastest flight and the cheapest one are considered. If there is any scale it is assumed in the trip time as a whole. Vienna and Budapest are by far the cities with more air connections in the region and, consequently, with more air passengers. However, Vienna two to three times more linked than Budapest. It has such a determinant influence in the airport choice from an air passenger. All the stats related to fares, time, the airlines that reign in those connections, the current air traffic and the number of direct commercial flights are gathered in the ANNEX 0; Departing airport – Arriving airport data.

Finally, the connection between the arriving airport and the destination is approached similarly to the origin to departing airport link. The possible and feasible access modes are studied for all the destinations, considering fare, time and frequency. In order to obtain a weighed average, our traffic modeling function is used. It is also swhon in the previous mentioned Annex both fare and time and the mode share. It is decided to gather all these information in the annex to have a lighter and more readable document.

Once stablished all the relations in the system, both for time and price values, it is to be solved the shortest path between all the origins and the six airports. Note that connections join nodes from the origin to the destination, the sum of the three cases just mentioned. If several arcs (road, railway or bus) connect two same cities, the traffic function is applied to simplify them to one arc based on a weighed average of its variables. Again, as a macro-regional approach and with the available data, a business-economic profile share is not worth to apply to every particular connection. It is assumed that the function itself considers both profiles.

The purpose lies in finding (dijkstra's algorithm) the cheapest way and the fastest route to get to each of the six airports from any of the cities in the region. After that, fare and time related to the departing-arriving airport connection and arriving airport to destination connection are added to each and every of the routes generated. Hence, the traffic function is applied to all of them, "forcing" the population to fly from all the departing airports. The total traffic in the system is finally obtained from the sum of all the partial traffics, and so is the share.

	Airport	Reality	Model			
			Same connections	1+ connection per week	3+ connection per week	1+ connection per day
Share	Belgrade	4,84%	5,19%	5,14%	5,05%	4,88%
	Bratislava	4,24%	3,40%	3,37%	3,31%	3,20%
	Budapest	**31,26%**	**31,78%**	**32,39%**	**33,58%**	**35,83%**
	Cluj-Napoca	4,09%	3,30%	3,27%	3,21%	3,11%
	Vienna	51,45%	51,34%	50,87%	49,98%	48,28%
	Zagreb	4,13%	5,00%	4,95%	4,86%	4,70%
Passengers variation	Belgrade	702.959	753.261	0	0	0
	Bratislava	614.914	493.280	0	0	0
	Budapest	**4.535.959**	**4.611.759**	**129.410**	**387.311**	**902.207**
	Cluj-Napoca	593.508	479.207	0	0	0
	Vienna	7.466.099	7.450.034	0	0	0
	Zagreb	599.138	725.036	0	0	0
Passengers generated			0	129.410	387.311	902.207

Table 8. *Share and passengers variation; Base Scenario*

Table 8 shows the results of the modeled reality from the share and passengers variation standpoint. Note as well that three more mini scenarios are been added to the base; Increasing the amount of direct commercial flights to all of its destinations studied one more per week, three more per week and one more per day.

The results suggest; the model approaches fairly the research problem as a macro-regionally speaking issue and an increase in the amount of connections would impact massively in a positive way the air traffic in the airport of Budapest. This hypothesis does not really depend in the access to the airport, but the access to the airport needs to be aware of those possible changes in the airlines' destinations route map so to afford such a demanding traffic.

Finally, none of the other airports is affected from this variation as no relative variable to the amount of direct connections is considered. Thus, it actually is translated in an increase of the air traffic in Budapest equal to the increase in the whole region and that is why the share for the others decrease.

6. EXTENSION OF THE MODEL: TESTING ALTERNATIVE POLICY SCENARIOS

6.1. Scenario A; Interurban Bus Network

The main intention of implementing an Interurban Bus Network connected to the airport of Budapest is based on giving a safer, faster and more reliable access. By improving it, more cities are directly connected to the airport, increasing the chance of spending less time and money on their journey and, consequently, enhancing the likeliness of flying from and to Budapest. Furthermore, the level of service still plays a major role. That is why reliability and good quality service are crucial for this mode of transport to keep having some share. Unfortunately, the data available is not enough to calibrate a precise function considering the resultant sensibility to this factor.

Regarding to the system, adding more connections to the airport from several nodes reduces the minimum price and time path from the majority of origins to the airport Budapest. However, it may have an impact on the straight connection and the price but not on the time. The railway system runs way faster and so does the road network.

From the point of view of modeling the air passenger's traffic in a multi airport hinterland thanks to a direct aggregated and continuous function, it is necessary to consider all sort of access to the airport. Note that each and every change in the network may alter the six airports passengers flow. And this is why some of the scenarios can show surprising results. The purpose is, based on aggregated data, increasing the traffic in the airport of Budapest. Connecting the airport right and straight to every major city can only have a positive impact in our aim.

Going through the design, the process is based on connecting directly to the Budapest airport all the cities with more than 100.000 population and the surrounding Hungarian cities linked to the current interurban bus network. Those to be considered and their new fare and time connections to the Airport of Budapest are gathered in Table 9.

The International Airport of Vienna (FlixBus, 2016) and (Orange Ways, 2016) and London Stansted Airport (Easy Bus, 2016) considered as good examples to design the network. Both run Interurban Bus Networks (Orange Ways and Easybus, among others) from the airport to several cities ranging from short distances to three hours ride in the case of Vienna's airport to Budapest, for example. Prices may differ considerably depending on the advanced booking time. That is a good way of meeting both business and economy passengers needs.

In the present scenario, an average price is provided instead of giving a range. The system works with minimum time and price path to the airport. In order to do so accurately, it should be split in two different cases from proven valid data. Moreover, offers or any kind of memberships are disregarded and so are different prices and time depending on peak hours.

City	Fare (euros)	Time (hours)	Daily connections
Vienna	10,00	3:30	5
Bratislava	8,00	3:15	5
Belgrade	20,00	5:30	2
Zagreb	17,00	5:00	0,5
Cluj - Napoca	21,00	6:20	2
Debrecen	10,00	2:21	18
Miskolc	8,00	1:53	18
Szeged	7,00	1:36	18
Pécs	10,00	2:30	18
Győr	9,73	2:03	18
Nyíregyháza	10,00	2:21	18
Kecskemét	5,00	0:48	18
Székesfehérvár	5,00	0:56	18
Szentes	8,65	1:34	18
Veszprém	8,65	2:30	18
Békéscsaba	11,76	3:20	18
Zalaegerszeg	14,54	3:45	18
Eger	7,54	2:30	18
Nagykanizsa	13,67	3:20	18
Hódmezővásárhely	10,78	2:05	18
Cegléd	1,65	0:25	36
Baja	10,78	3:35	18
Szekszárd	9,73	3:10	18
Pápa	11,76	2:55	18
Gyula	12,75	3:45	18
Esztergom	3,43	1:15	36
Kiskunfélegyháza	7,54	1:55	18
Ajka	9,73	3:00	18
Graz	19,00	4:14	5
Košice	10,00	3:18	4
Novi Sad	20,00	4:30	2
Subotica	12,75	4:35	2
Osijek	15,00	3:30	2
Timișoara	21,00	4:30	4
Oradea	21,00	4:00	2
Arad	21,00	4:00	2
Baia Mare	21,00	4:53	2
Satu Mare	21,00	4:10	2
Turda	21,00	8:10	2
Ivano-Frankivsk	25,00	7:30	2

Table 9. *Interurban Bus connections to Liszt Ferenc International Airport*

This is the change (Fig. 6 and Fig. 7) generated in the minimum price and time "catchment area" compared to the current situation, respectively. As it was mentioned before, note that a better "catchment area" cannot be obtained as our model resulted massively related to the amount of direct commercial flights and, despite modeling quite well total aggregated values, it lacks some accuracy at a local-regional level.

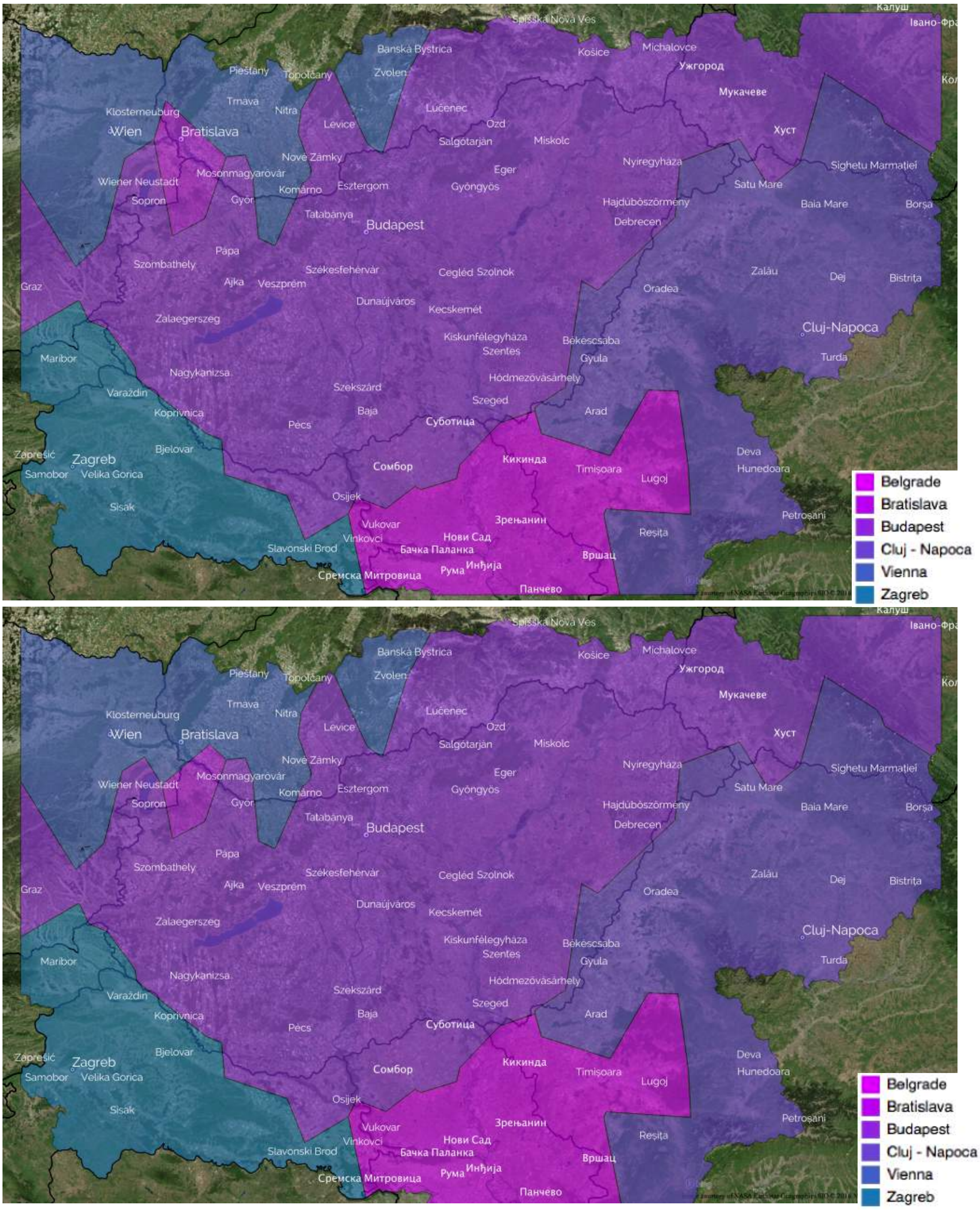

Fig.6 and Fig. 7. *"Cathment area" related to the fare and time access to the airport; Scenario A*

Mark that is not the connection to Budapest but to the airport of Budapest what is considered. The main discrepancy is that this scenario is expected to impact directly and positively the amount of air passengers in the airport of Budapest as the connections are only changed in the access to the airport. The ones who acknowledge such improvement are the ones who actually use the airport of Budapest. As a result of the change in relative times and prices, the air passenger's flow in the rest of airports is expected to decrease.

If changes were applied to Budapest, the effect would be on the system as a whole. As Budapest is placed in the center of the hinterland, the connections all over the region would be strengthened, even from one side to the other. That is why and given the importance of the amount of annual direct commercial flights assured from the origin airport to the destination airport, it would be no surprise if Vienna was more benefited from it rather than Budapest despite connecting radially the second one. But this hypothesis is specified in the scenarios E and F.

Table 10 shows the results for the current Scenario. Note that an other sub-scenario has been studied and will be reproduced for the ones to come. It consists on considering that the air ticket fare assumes the access to the airport fare. There is no precedent about this initiative but as competition is getting tougher and rougher, it would be no surprise that airlines and local administrations started applying agreements to this sort of approach.

	Airport	Reality	Model; Scenario A	
			Same fare	Free fare
Share	Belgrade	4,84%	5,09%	5,01%
	Bratislava	4,24%	3,31%	3,26%
	Budapest	**31,26%**	**32,73%**	**33,79%**
	Cluj-Napoca	4,09%	3,25%	3,19%
	Vienna	51,45%	50,74%	49,95%
	Zagreb	4,13%	4,88%	4,80%
Passengers variation	Belgrade	702.959	-9.374	-18.815
	Bratislava	614.914	-12.633	-20.919
	Budapest	**4.535.959**	**162.724**	**326.662**
	Cluj-Napoca	593.508	-6.733	-15.885
	Vienna	7.466.099	-44.330	-142.861
	Zagreb	599.138	-10.336	-18.317
Passengers generated			79.318	109.865

Table 10. *Share and passengers variation; Scenario A*

Some statements can be pulled out from those results. First of all, it would mean close to a 4% increase in the total amount of air passengers flying from Budapest to those destinations, totaling over 160.000 people. Oppositely and thanks to the relative parameters, the other airports would be disadvantaged, specially Vienna. The ones who have less stake in the network are the one who have less to lose in any disturbance. Being straight, Budapest would mainly get passengers from Vienna. However, it would also generate passengers in the system increasing the likability to fly from the region.

Applying this initiative or at least, applying some sort of reduced fare, would have even greater positive results in Budapest. Sooner or later, it is something worth to consider.

6.2. Scenario B; Interurban Railway Network

Similarly to the first scenario, providing a safer, with a higher capacity, faster and more reliable access to the airport of Budapest emerges as the main purpose and motivation to implement it as to improve the likeliness to fly from and to Budapest. Over a 40% of the 150 largest airports by passenger has a rail connecting to the airport (Organisation for Economic Co-operation and Development, 2014).

Both scenarios are split as they need to be considered and approached differently. The truth is that the results can happen to be the same (or similar at least) in our system based on its time, price, frequency and disregarding preferences, sensibilities and the passenger's profile. However, none of them exists in the current access to the airport network and it is to be strongly required to implement them. The aggregated cost and time of initial usage might differ widely and so they do encourage the scenarios to split.

In order to fathom in the comparison between both scenarios, the current network needs to be understood. The current railway network in Hungary spreads all over the country radially, ensuring that all the cities are connected to the Budapest. Nonetheless, the high-speed railway is not offered in all the connections so you can find yourself spending about 8 hours in the train from Belgrade to Budapest when less than 400 kilometers separate them. Most of the network is run by a regional service that stops almost in every city and does not reach high speed. It is mainly believed in the present paper that a closer consideration on improving the railway access to the airport of Budapest needs to be considered to accomplish the best outcome. Competitive fare tickets and, more important, a fast and reliable service would definitely increase the likeliness of flying from Budapest. Thus, a case study (Organisation for Economic Co-operation and Development, 2014) of the effects of the introduction of rail way modes in the access to the airport competition is considered. Four major airport-city railway connections in Europe; London Heathrow, London Gatwick, Oslo Gardermoen and Stockholm Arlanda. The running associated services are, respectively, Heathrow express, Gatwick express, Flytoget and Arlanda Express.

It is suggested (Organisation for Economic Co-operation and Development, 2014) that for the appropriate performance of the a decent railway network some requirements need to be achieved. First of all the fare. Providing a a good quality service with high capacity allows the railway to ask for a more expensive fare. Oslo considers up to a 30% higher price than the interurban bus connection but still has a decent share. Arlanda and Heathrow, on the opposite, charge twice the price than the cheapest mode, losing some stake to the other modes. In relation to that, the introduced connections are priced following the current pattern and, in case of Hungarian cities, the fare is calculated depending on the distance as it actually works.

Secondly, the integration of the airport real station into the airport terminal. it is to be considered for further studies if considering all the times a part from the in vehicle travel time. If so, this measure means such a fair decrease on the travel time and even more important, has psychological impact on the passenger as a good quality access.

After that, the time factor is an advantage over the other modes. It goes hand by hand with the fare as it is always a trade off. However, the railway network has always the last call as it mostly provides the best service. In the present scenario, high-speed railway was considered for the connections to cities with more than 100.000 people. Thus, average speeds ranging from 100-150 km/h are assumed (depending on the route and how challenging might be the relief).

Finally, the direct access to the city center was determinant in the four cases studied. In the present scenario, it is only improved the connectivity mainly by creating non-existing links. The current relationship between Budapest and the Airport of Budapest is to be checked in the scenario C. Furthermore, the scenario D assumes A, B and C all together, finally checking the direct access to the city center box.

Back to the design, the process was based on connecting the cities that total in more than 100.000 population and the Hungarian cities linked to the current interurban bus network. Those to be considered and their new fare and time connections to the Airport of Budapest are shown in the table 11. Note that if several arcs happen to connect the same nodes the abstract aggregated traffic function is applied to get the weighed average of the parameters. After that, the whole process is replied finding the shortest path and modeling the partial and total traffic. Those are the results obtained from the initiative studied in this scenario shown in Table 12.

Mark again that the system is only affected by the changes of fare, time and frequency of the mode improved. That is why the results are expected to be quite similar to the scenario A, putting Budapest in a position of dominance respect the current situation. The data mentioned for both the cities and the results follow:

The general results (table 12) are quite similar to the ones from the previous scenario but a little bit more exacerbated. Then, despite fares being more expensive than the interurban bus network, more passengers would fly from Budapest. A part from that, a decrease in time means a lower passengers generation in the whole section than the interurban bus connection, less price. That is why and from a macro-regional standpoint, it is understood that globally, reducing price in the network generates more passengers than reducing time.

It actually is deducted form the function parameters. The function denoted that the traffic is more sensitive to variations in time. As long as flying from Budapest in this region means most of the times the shortest travel time, the relative time for Budapest is almost always 1. Then, decreasing time has a more positive effect than the interurban bus network in the generation of passengers in Budapest.

Furthermore, note that the free fare sub-scenario generates a wider margin of passengers from the base scenario B than in the previous one from the base scenario A.

City	Fare (euros)	Time (hours)	Daily connections
Vienna	13,00	2:53	9
Bratislava	8,00	2:38	9
Belgrade	15,00	7:56	3
Zagreb	29,00	6:55	2
Cluj - Napoca	19,00	6:56	3
Debrecen	14,24	2:14	18
Miskolc	12,33	1:42	18
Szeged	11,76	2:22	18
Pécs	14,24	2:55	18
Győr	9,22	1:35	18
Nyíregyháza	15,94	2:44	18
Kecskemét	7,54	0:40	18
Székesfehérvár	4,60	1:00	18
Szombathely	14,94	2:54	18
Szolnok	2,54	1:10	36
Tatabánya	4,13	0:52	18
Szentes	10,59	2:18	18
Veszprém	6,98	1:47	18
Békéscsaba	11,76	2:15	18
Zalaegerszeg	13,67	3:40	18
Eger	8,65	1:35	18
Nagykanizsa	13,67	3:06	18
Dunaújváros	4,73	1:27	18
Hódmezővásárhely	14,05	2:50	18
Cegléd	4,73	0:40	36
Baja	10,98	2:38	18
Salgótarján	8,48	2:24	18
Ózd	14,05	3:10	18
Szekszárd	10,03	2:12	18
Gyöngyös	6,38	1:08	18
Pápa	12,05	2:36	18
Gyula	12,65	2:42	18
Esztergom	3,56	1:13	36
Kiskunfélegyháza	7,54	1:40	18
Ajka	9,73	3:15	18
Graz	19,00	5:05	5
Košice	19,00	3:05	4
Novi Sad	12,00	6:08	2
Subotica	15,60	3:15	2
Osijek	18,00	3:11	2
Timișoara	15,00	4:49	4
Oradea	20,60	4:18	2
Arad	21,10	3:56	2
Baia Mare	32,30	9:45	2
Satu Mare	27,50	9:00	2
Ivano-Frankivsk	35,00	10:00	2

Table 11. *Interurban Railway connections to Liszt Ferenc International Airport*

But it only happens globally speaking. Note that locally, providing a free access to the airport has a major impact in the Scenario A locally for every mode. As it was mentioned before, this free fare helps the interurban bus network counterbalance the better service, quality and time the railway system may generate.

Hence, a larger improvement is deducted from the initiative as there is more to improve. As the railway network is already better, there is less to improve significantly.

	Airport	Reality	Model; Scenario B	
			Same fare	Free fare
Share	Belgrade	4,84%	5,08%	5,02%
	Bratislava	4,24%	3,31%	3,26%
	Budapest	**31,26%**	**32,92%**	**33,69%**
	Cluj-Napoca	4,09%	3,24%	3,19%
	Vienna	51,45%	50,58%	50,02%
	Zagreb	4,13%	4,87%	4,81%
Passengers variation	Belgrade	702.959	-12.466	-17.972
	Bratislava	614.914	-14.414	-20.085
	Budapest	**4.535.959**	**183.155**	**310.862**
	Cluj-Napoca	593.508	-8.565	-15.220
	Vienna	7.466.099	-78.947	-133.530
	Zagreb	599.138	-12.960	-17.412
Passengers generated			55.804	106.642

Table 12. *Share and passengers variation; Scenario B*

Last but not least, this is the "catchment area" regarding to time and price access from every city in the region to any of the 6 studied airports.

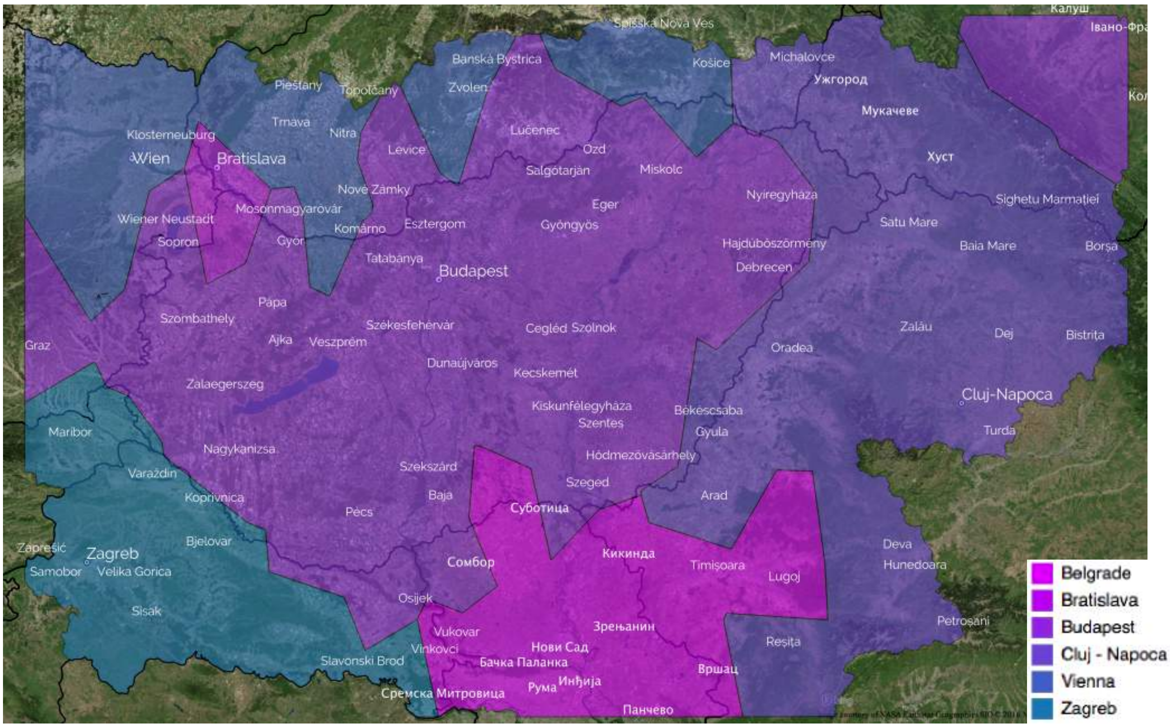

Fig. 8. *"Catchment area" related to the fare access to the airport; Scenario B*

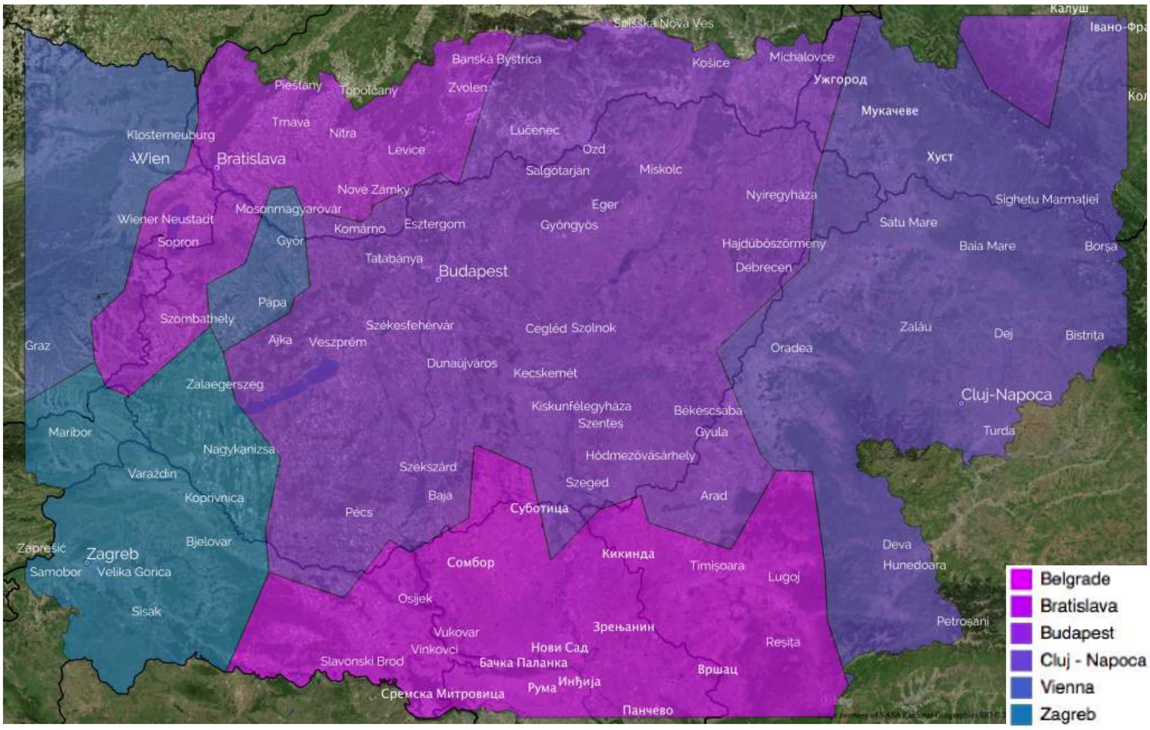

Fig. 9. *"Catchment area" related to the time access to the airport; Scenario B*

6.3. Scenario C; Improving the connection from Budapest to Liszt Ferenc International Airport

The connection between Budapest and Liszt Ferenc International Airport is, probably, one of the main concerns that should be integrated in any plan enhancing a better access to the airport. As it was detailed in the base scenario, five main modes of transport run the connection. Those are the taxi, the Uber, the Shuttle Bus, the car and the public transportation. The last one is not split into bus, metro or railway for two reasons. The first one is that there is no railway link to the airport. The second and yet more important, that there is no feasible straight connection from the city center to the airport. Instead, a combination of metro and bus is suggested.

Find again in table 7 the results conducted from the survey and the respective average fare and time.

The modal share is varied and enough to host an increase in the air passengers demand. It also offers a good range of possibilities with quite different qualities that may finally adapt to each and every passenger profile. However and despite having quite a good modal share, the fact that there public transportation connection cannot be achieved through just one mode, may be a short term obstacle in affording the increasing demand that Budapest is about to face with, trends say.

Furthermore, the improvement suggested means way more than just avoiding transfers. It is a quality service level and it was also mostly depicted in the survey. Most of the people pointed out the lack of accessibility to information in the connection, specially when going from the airport to the city. Those complaints referred to the misunderstanding of the language (most of signs are in Hungarian) and of the ticketing procedure. However, it is fair to say that this situation has experienced a clear improve during the last year and will keep on doing it, for example, as Budapest hosts in July 2017 the FINA World Championships.

In order to cope with that, Barcelona's (TMB, 2016) new metro connection with Aeroport del Prat is used as an example of pricing and frequency. Note that Budapest distances a little bit more from the airport than Barcelona, but in both case it supposed and would suppose extending the current metro line to the not so populated regions surrounding the airport actually.

The Budapest airport corridor has gained some importance in the recent years. Marking this eighteen kilometers axis from Kálvin tér to the airport, it is place to the main international bus station (Népliget), the new Ferencváros football stadium, some internationally recognized and well-known universities like Semmelweis Medical Univeristy and a large range of museums as well like the National Museum, for example. It also is surrounded by several leisure and economical clusters in Corvin and Kőbánya (Város-Teampannon Ltd , 2014).

However and as it was stressed previously, there is no feasible straight connection to the airport without using at least two modes of transport. The extension of the metro line 4, now reaching into Kőbánya-Kispest, requires 8-9 kilometers more to get to the airport. Following Barcelona's example, 4-6 metro stops would be enough given that most of the urbanization is already solved by the current line coverage. In addition to that, three different departing points for a direct bus connection to the airport are suggested, those leaving from Deák Ferenc tér, Keleti Pályaudvar and Keleföld Vasútállomás. Similarly, fare and frequency is adapted from the "aerobus" mode in Barcelona, given the good functioning of the service in this city.

The new scenario presents one extra mode and a change in time, price and frequency. It is worth to mark the importance of the abstract aggregated modeling approach in that sense, as it handles the variation of modes very well and this was one of the main reasons to apply it to the study. At the same time, providing more and better information in English that ensures the right communication from the city center, would be extremely appreciated for those who are not in Budapest for a long stay and are not used to that journey.

As a matter of the new characteristics, the same increase in the single ticket fare in Barcelona to get to the airport is applied in the case of Budapest. This would make a 730 ft (2,32 euros) metro ticket. Regarding to the bus, the same methodology is applied from the "aerobus" pricing, now being 975 ft (3,10 euros). Note that the current public transportation access is about 530 ft (1,68 euros). As for the timing, three scenarios are differentiated; full frequency (every 3 minutes), mid frequency (every 5 minutes) and low frequency (every 10 minutes). All of them combined accurately and providing a longer service on Friday and non-stop on Saturday. Again, the same methodology applies to the bus connection. The impact on the weighed fare and time to the airport is a decrease of almost 3 euros (34%) and 2 minutes (5,15%). The results regarding to the whole system are the following:

	Airport	Reality	Model; Scenario C	
			Same fare	Free fare
Share	Belgrade	4,84%	5,15%	5,13%
	Bratislava	4,24%	3,36%	3,31%
	Budapest	**31,26%**	**32,02%**	**32,41%**
	Cluj-Napoca	4,09%	3,30%	3,28%
	Vienna	51,45%	51,23%	50,94%
	Zagreb	4,13%	4,95%	4,93%
Passengers variation	Belgrade	702.959	-4.739	-9.171
	Bratislava	614.914	-7.378	-17.774
	Budapest	**4.535.959**	**35.289**	**82.314**
	Cluj-Napoca	593.508	-509	-4.416
	Vienna	7.466.099	-14.000	-68.720
	Zagreb	599.138	-5.798	-8.904
Passengers generated			2.865	-26.670

Table 13. *Share and passengers variation; Scenario C*

The conclusion about those results can be mainly extracted from the relative parameters. First of all, note that this measure does not strictly imply a great improvement in the air passengers volume through the airport of Budapest. It is believed that the function underestimates the real traffic because, this improvement in the network is expected to have a wider share than it actually has. However, this range of possible modes of access and the high availability they offer (Taxi, Car, Uber and Shuttle Bus), help the average fare to increase from the one the metro or bus suggests. Consequently and from a macro-regional standpoint, a decrease of 3 euros in the total trip fare and 2 minutes, can be an improvements of the total journey of less than a 2% and a 1%, respectively.

On the other hand, it is believed that the lack of sensitivity of the model when adding a new mode is the main responsible for this bare improvement. The system acknowledges the presence of an other mode and the change of its characteristics. Nonetheless, the real impact on the population's mindset generated cannot be pictured. Note that it is believed that this factor is more important in this scenario than in the previous ones as Budapest is far more populated than the rest of the cities and most of the departing and arriving passengers leave from or arrive to Budapest.

As for the relative parameters, those are responsible for the loss of traffic through the other airports. Assuming that Budapest is, in most of the cases, the shortest and cheapest option to fly from, the better connection from the city center to the airport just impacts on those who travel from Budapest, decreasing the trip fare and time. If so, the relative time and fare parameters increase for the others, having a negative effect on the traffic. And this is strongly clarified for "free fare" sub-scenario, even achieving a loss in the total passengers generated in the region. As it should be, it is believed that the traffic in Budapest should counterbalance this loss. Lastly, Fig.10 and Fig.11 show the "catchment area" regarding to fare and time access to the airports.

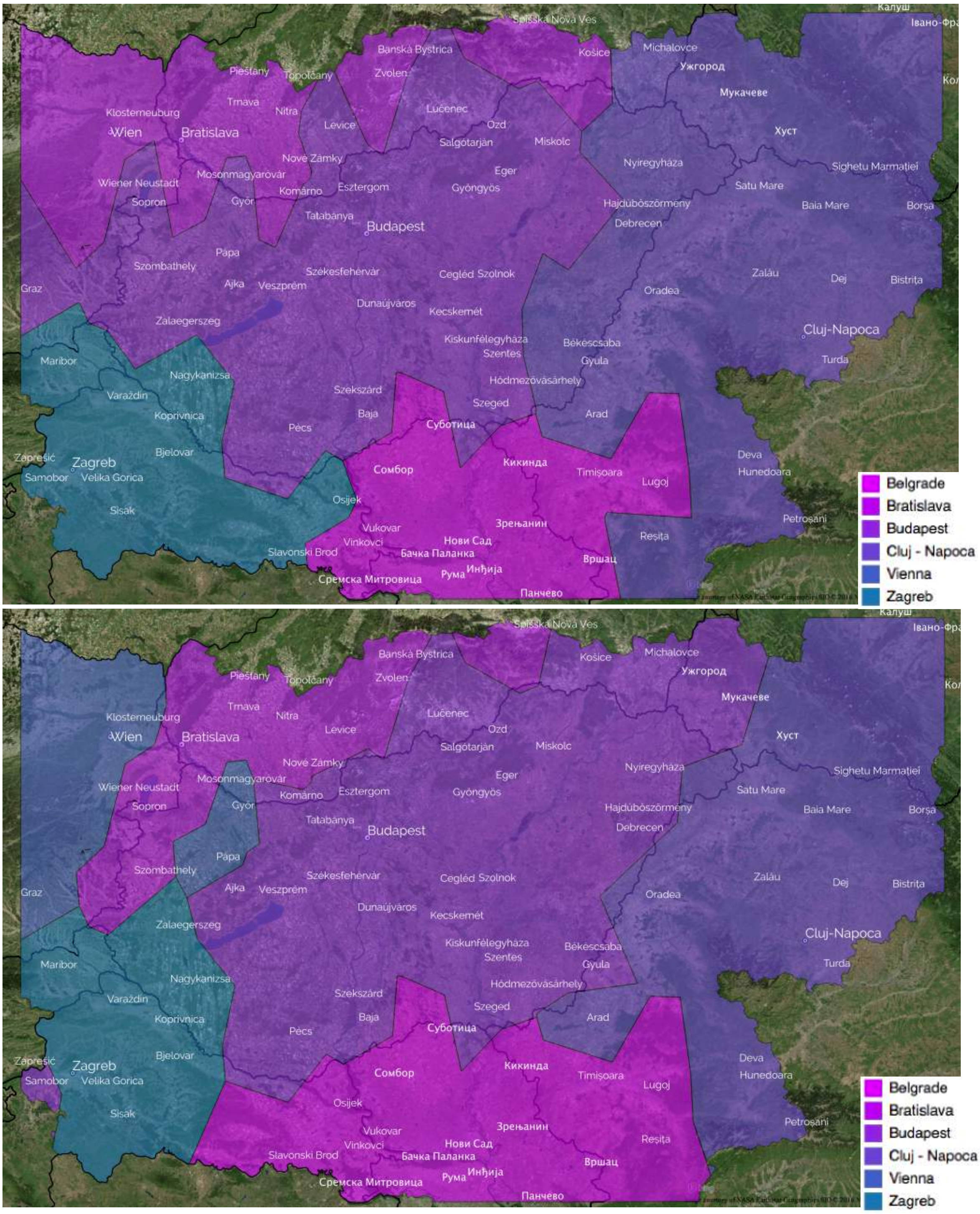

Fig.10 and Fig. 11. *"Catchment area" related to the fare and time access to the airport; Scenario C*

6.4. Scenario D; A + B + C

The aim of this scenario is considering all previous three together so we can better understand the implications of introducing such a significant change in the system. Now, the weighed fare and time average have to be applied to all the connected cities as, at least, they now have both railway and bus connections. Those are the cities and the fare and time of the connections.

City	Fare (euros)	Time (hours)
Budapest	7,96	0:35
Vienna	11,93	3:06
Bratislava	8,00	2:51
Belgrade	16,93	6:59
Zagreb	23,03	6:05
Cluj - Napoca	19,79	6:41
Debrecen	12,11	2:17
Miskolc	10,14	1:47
Szeged	9,41	1:59
Pécs	12,13	2:42
Győr	8,11	1:33
Nyíregyháza	12,97	2:32
Kecskemét	19,14	0:54
Székesfehérvár	20,98	1:03
Szombathely	14,73	3:50
Szolnok	2,54	0:57
Tatabánya	20,71	1:06
Szentes	9,63	1:56
Veszprém	7,83	2:08
Békéscsaba	11,76	2:48
Zalaegerszeg	14,10	3:42
Eger	8,08	2:03
Nagykanizsa	13,67	3:13
Dunaújváros	21,78	1:18
Hódmezővásárhely	12,43	2:27
Cegléd	11,44	0:44
Baja	10,88	3:06
Salgótarján	26,23	1:54
Ózd	36,53	3:02
Szekszárd	9,88	2:41
Gyöngyös	18,89	1:06
Pápa	11,90	2:45
Gyula	12,70	3:13
Esztergom	16,22	1:24
Kiskunfélegyháza	7,54	1:47
Ajka	9,73	3:07
Graz	19,00	4:56
Košice	11,27	2:52
Novi Sad	19,22	4:39
Subotica	13,01	4:27
Osijek	15,28	3:28
Timișoara	19,94	4:33
Oradea	20,96	4:33
Arad	21,01	3:59
Baia Mare	22,11	5:21
Satu Mare	21,64	4:38
Ivano-Frankivsk	25,95	7:44

Table 14. *Interurban connections to Liszt Ferenc International Airport*

The results obtained from the combination of three are the following:

<table>
<tr><th rowspan="2"></th><th rowspan="2">Airport</th><th rowspan="2">Reality</th><th colspan="2">Model; Scenario D</th></tr>
<tr><th>Same fare</th><th>Free fare</th></tr>
<tr><td rowspan="6">Share</td><td>Belgrade</td><td>4,84%</td><td>5,11%</td><td>5,02%</td></tr>
<tr><td>Bratislava</td><td>4,24%</td><td>3,32%</td><td>3,26%</td></tr>
<tr><td>Budapest</td><td>31,26%</td><td>32,43%</td><td>33,69%</td></tr>
<tr><td>Cluj-Napoca</td><td>4,09%</td><td>3,26%</td><td>3,19%</td></tr>
<tr><td>Vienna</td><td>51,45%</td><td>50,97%</td><td>50,02%</td></tr>
<tr><td>Zagreb</td><td>4,13%</td><td>4,90%</td><td>4,81%</td></tr>
<tr><td rowspan="6">Passengers variation</td><td>Belgrade</td><td>702.959</td><td>-6.917</td><td>-17.670</td></tr>
<tr><td>Bratislava</td><td>614.914</td><td>-10.317</td><td>-20.284</td></tr>
<tr><td>Budapest</td><td>4.535.959</td><td>119.263</td><td>313.047</td></tr>
<tr><td>Cluj-Napoca</td><td>593.508</td><td>-4.500</td><td>-15.146</td></tr>
<tr><td>Vienna</td><td>7.466.099</td><td>-12.245</td><td>-130.595</td></tr>
<tr><td>Zagreb</td><td>599.138</td><td>-8.098</td><td>-17.243</td></tr>
<tr><td colspan="3">Passengers generated</td><td>77.186</td><td>112.109</td></tr>
</table>

Table 15. *Share and passengers variation; Scenario D*

Several surprising conclusions just jump from the results. Comparing it to the previous scenarios traffic data, there is a major highlight; the total traffic from the combination of several modes of transport does not imply an increment respect their partial traffic.

Unfortunately, this is a result from the assumptions and structure of the model applied. And this is why. It is decided to study the region from a macro point of view. It means that we don't focus on the traffic between all the possible nodes but just from the origin to destination ones. Therefore, our modes of transport, as matter of the different ways a passenger can be connected from the origin to any of the twenty-two destinations studied, refer to the six routes available through each departing airport, no matter the mode of transport used in the access to that, only the characteristics provided.

Translated into the system and considering as a mode of transport "flying from Budapest", adding a new mode on the way to the airport just changes the fare and time of the final arc remaining between a given node. Therefore, instead of having two different partial traffics, now we have only one with the combination of the characteristics that will be not as cheap as the cheapest and not as fast as the fastest. Consequently, a more than probable decrease in the air traffic generation.

Despite this limitation and acknowledging it even before starting the study, it was decided to disregard the route selection and leave it for further studies. The attractiveness between a given origin and a given destination its not the sum of the attractiveness of the connections on the way. That is why it was decided not to apply the traffic function to every connection from a micro-regional standpoint. Moreover, as a computational simplification it was decided not to reply the traffic model from every origin to every destination and through every mode of transport and every every airport.

Finally, this is the "catchment area" for the present scenario:

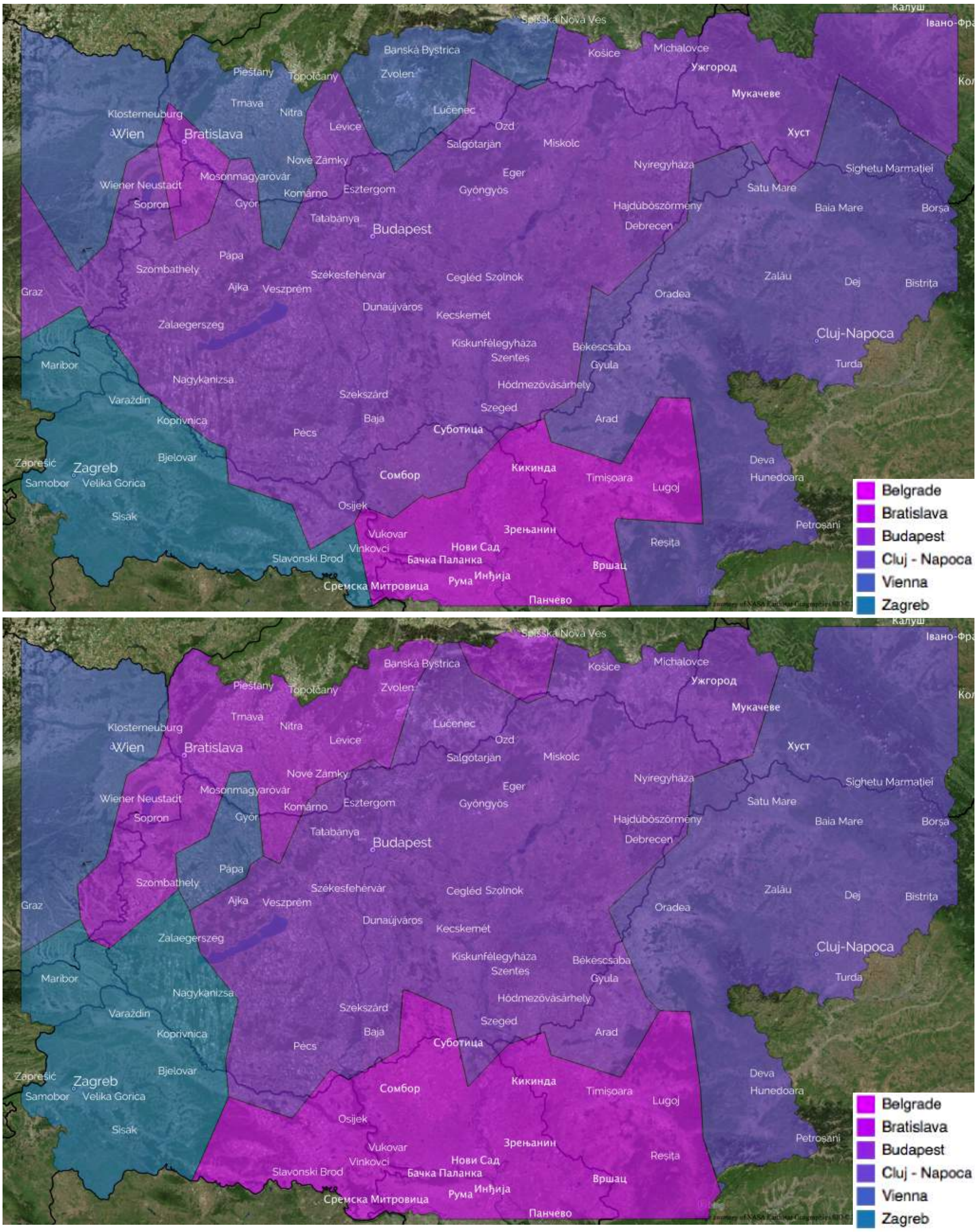

Fig.12 and Fig. 13. *"Catchment area" related to the fare and time access to the airport; Scenario D*

6.5. Scenario E; Doubling the amount of Interurban Railway connections to Budapest

This scenario aims to study the impact of improving the interurban railway connection of Budapest and check wether is a better choice to consider compared to the interurban railway connection of the Liszt Ferenc International Airport. At the moment, the existent railway connection of Budapest links with the next cities, times, fares and amount of daily connections (one way). Despite reaching to most of the region considered,the road connection still prevails as the fastest mode of transport.

City	Fare (euros)	Time (hours)	Daily connections
Vienna	13,00	2:54	10
Belgrade	15,00	7:56	4
Zagreb	29,00	6:01	6
Cluj - Napoca	19,00	14:06	4
Debrecen	14,24	2:29	28
Miskolc	12,33	1:57	28
Szeged	11,76	2:22	28
Pécs	14,24	2:55	42
Győr	9,22	1:20	34
Nyíregyháza	15,94	2:59	4
Kecskemét	7,54	1:17	28
Székesfehérvár	4,60	0:45	56
Szombathely	14,94	2:39	6
Szolnok	2,54	1:17	42
Tatabánya	4,13	0:52	72
Szentes	10,59	2:33	36
Veszprém	6,98	1:32	158
Békéscsaba	11,76	2:30	44
Zalaegerszeg	13,67	3:25	32
Sopron	15,03	2:33	34
Eger	8,65	1:50	50
Nagykanizsa	13,67	3:21	20
Dunaújváros	4,73	1:27	30
Hódmezővásárhely	14,05	3:05	18
Cegléd	4,73	0:54	72
Baja	10,98	2:53	62
Salgótarján	8,48	2:39	48
Ózd	14,05	3:25	44
Szekszárd	10,03	2:12	14
Mosonmagyaróvár	10,78	1:39	36
Gyöngyös	6,38	1:23	300
Pápa	12,05	2:21	18
Gyula	12,65	2:57	36
Hajdúböszörmény	15,03	3:08	36
Esztergom	3,56	1:13	344
Kiskunfélegyháza	8,65	1:34	60
Ajka	9,73	2:02	20
Graz	19,00	4:50	4
Novi Sad	12,00	6:23	2
Subotica	15,60	3:29	4
Timișoara	15,00	5:04	6
Oradea	20,60	4:33	6
Arad	21,10	4:11	6
Baia Mare	32,30	10:00	6

Table 16. *Interurban Railway Connections to Budapest*

Doubling the interurban railway network connection to Budapest would seem to impose an increase in the air passengers traffic. However, exactly the opposite happened and Vienna's airport was actually the truly benefited of such change. The share and variation of total passengers is shown in the Table 17.

	Airport	Reality	Model; Scenario E	
			Same fare; double bus connections	Same fare; double bus connections + Scenario C
Share	Belgrade	4,84%	5,14%	5,12%
	Bratislava	4,24%	3,35%	3,34%
	Budapest	**31,26%**	**31,61%**	**31,81%**
	Cluj-Napoca	4,09%	3,29%	3,28%
	Vienna	51,45%	51,68%	51,53%
	Zagreb	4,13%	4,92%	4,91%
Passengers variation	Belgrade	702.959	-4.660	-5.635
	Bratislava	614.914	-6.086	-6.912
	Budapest	**4.535.959**	**-5.956**	**27.272**
	Cluj-Napoca	593.508	597	-731
	Vienna	7.466.099	79.199	66.933
	Zagreb	599.138	-6.645	-7.020
Passengers generated			56.449	73.908

Table 17. *Share and passengers variation; Scenario E*

To better understand why, it's necessary to mark some bold statements. First of all, note that doubling the frequency of the railway network has an effect mainly in regional relations. If there are several arcs between two nodes, now the frequency plays a role. If not, remember that just time and fare are considered. Moreover, the frequency of each and every partial traffic calculated refers to the direct commercial flights between departing and arriving airport as it sets the lowest amount of connections limit. Furthermore, again individuals preferences are disregarded.

The abstract aggregated modeling approach invites to believe that improving the connection to Budapest without doing the same with the airport can be not only useless but "harmful". Categorizing the system as time and price connections of the center of the region, Budapest, leads to improving significantly the connection from west to east and vice versa, and from east to south. The reason lies in two factors. The first one is that the connections to Budapest when flying from the same have almost no minimum time and fare change as far as the road transport is still predominant. The second one is, regarding to the others, they experience a time and fare decrease. For long distances, a good railway connection can surpass the road usage as a matter of being cheaper. So, a reduction in time and fare for some of the other airports impacts positively in their traffic and negatively to Budapest. As price and time almost remain the same, the relative time and fare don't, as they depend on the minimum fare and time present in the system from a same given origin.

Far from rejecting those results as they mean something true in the system, it is worth to mention and encourage a continuous approach to this traffic modeling to better predict the results, as it is expected to have a better impact in Budapest than the obtained and consequently a lower increase regarding to Vienna's airport.

Finally, note that it has also been studied a combination with scenario C in order to solve this decrease of total passengers flying from Liszt Ferenc International Airport. The second, as mentioned in Scenario C, handles a positive effect on Budapest as long as the only ones who acknowledge such change in the system are the ones who fly from Budapest. However, almost every passenger in the system is benefited from the Scenario E.

As for the "catchment area" Fig. 4 and Fig, 5 in the Base Scenario depict as well the present one

6.6. Scenario F; Doubling the amount of Interurban Bus connections to Budapest

Similarly to the previous scenario, this one strives to on the one hand, check wether the interurban bus network can have a positive impact on the air passenger's flow in the airport of Budapest and on the other hand, compare the results with the interurban railway connection improvement. This scenario is important as well in order to check if the previous results are random or, otherwise, to confirm its validity. Again but now focused on the interurban bus network, Budapest is linked to the following cities, times, fares and amount of daily connections (one way). Despite reaching to most of the region considered,the road connection still prevails as the fastest mode of transport.

As expected from the previous results, Vienna is again the beneficiary of this network improvement. The results regarding to the airport's share and the total amount of passengers generated is shown in Table 19.

The results obtained are exactly the same as the previous scenario. It means that in spite of comparing completely different networks, the characteristics are still similar. The railway network provides fester routes whereas the bus network offers in most of the cases cheaper fares. However and all together, both changes seem not to impact in any kind of way the minimum fare and the minimum time of access to the airport of Budapest.

Regarding to the time, road connection still prevails as the main contributor to the fastest route from any close origin to the airport, where the regional frequency is improved. Moreover, and as mentioned in the previous scenario, doubling the frequency of the interurban bus network has an impact locally when 2 or more arcs between two given nodes are present. Thus, such increase in the frequency may alter barely the system regarding to price and time. And this is why. If the arcs for the same connection refer to bus and train, as they both have similar characteristics, the time and fare doesn't experience much of a change. If any of the arcs comprises the road network, the change is even less. Note that the function obtained is strongly related to the amount of direct connections from origin to destination, far over than the rest of parameters. The car is expected to available during a certain hours considered for working days and weekends as well, but still is way more available than any other mode of transport. So, introducing this double network connection doesn't really alter the existing pattern.

City	Fare (euros)	Time (hours)	Daily connections
Vienna	10,00	3:10	10
Bratislava	8,00	3:00	8
Belgrade	20,00	5:30	2
Zagreb	17,00	5:00	4
Cluj - Napoca	21,00	6:40	6
Debrecen	12,75	3:20	8
Szeged	10,78	3:00	16
Pécs	12,75	4:30	28
Győr	8,65	1:48	8
Nyíregyháza	13,67	3:40	4
Kecskemét	5,81	1:10	128
Székesfehérvár	4,60	1:15	158
Szombathely	13,67	4:25	8
Tatabánya	4,60	1:02	48
Szentes	9,73	1:54	32
Veszprém	7,54	2:10	32
Békéscsaba	12,75	3:40	24
Zalaegerszeg	13,67	3:25	90
Eger	8,65	2:50	126
Nagykanizsa	12,75	3:00	22
Dunaújváros	6,38	2:00	264
Hódmezővásárhely	10,78	2:25	50
Baja	10,78	3:35	24
Salgótarján	8,65	3:00	168
Ózd	11,76	4:10	16
Szekszárd	9,73	3:10	154
Gyöngyös	5,21	1:50	18
Pápa	10,78	2:35	18
Gyula	13,67	4:05	18
Esztergom	3,43	1:15	70
Kiskunfélegyháza	7,54	1:55	90
Ajka	9,73	2:41	42
Nitra	10,00	4:30	2
Banská Bystrica	13,00	6:05	2
Zvolen	25,20	12:35	2
Novi Sad	20,00	4:30	6
Subotica	12,75	4:35	6
Oradea	21,00	4:55	6
Turda	21,00	8:30	6

Table 18. *Interurban Bus Connections to Budapest*

Moreover, it is again considered an other sub-scenario combining this approach with the scenario C, improving the connection from the city center of Budapest to the airport. It helps overcome this lack of flow promoted from doubling the interurban bus network, but

Vienna still would be the main benefited.

	Airport	Reality	Model; Scenario F	
			Same fare; double bus connections	Same fare; double bus connections + Scenario C
Share	Belgrade	4,84%	5,14%	5,12%
	Bratislava	4,24%	3,35%	3,34%
	Budapest	**31,26%**	**31,61%**	**31,81%**
	Cluj-Napoca	4,09%	3,29%	3,28%
	Vienna	51,45%	51,68%	51,53%
	Zagreb	4,13%	4,92%	4,91%
Passengers variation	Belgrade	702.959	-4.660	-5.635
	Bratislava	614.914	-6.086	-6.912
	Budapest	**4.535.959**	**-5.956**	**27.272**
	Cluj-Napoca	593.508	597	-731
	Vienna	7.466.099	79.199	66.933
	Zagreb	599.138	-6.645	-7.020
Passengers generated			56.449	73.908

Table 19. *Share and passengers variation; Scenario F*

Finally and to back our conclusions, picturing again the fare and time "catchment areas", they show no change from the reality ones. Fig. 4 and Fig. 5 in the Base Scenario show it precisely.

6.7. Scenario G; Reduction of the time spent crossing the borders

The main purpose of this scenario lies in studying how changing a current geopolitical issue would impact on the air passenger traffic among the delimited region. When switching countries and mainly by bus or railway, there is some extra time spent due to an exhaustive control.

The reason why this happens may be a consequence of a couple of facts. First of all, the status of the countries. Serbia is not in the European Union and Romania and Croatia are not Schengen States[8], despite being legally obliged to join. Secondly, the recent raised tension among Hungary and surrounding countries in the South because of the Refugees migration.

All together, derives in an obstacle not only for local flow of people but also for the air

[8] Schengen Area, named after "the Schengen Agreement" signifies a zone where 26 different European nations, acknowledged the abolishment of their internal borders with other member nations and outside, for the free and unrestricted movement of people, goods, services, and capital." (Shengen Visa, 2016)

passengers airport's choice. There is no exact data that quantifies the time spent in the countries boundaries as it may depend on the nationality of the passenger, the capacity of the mode of transport used, etc. It is suggested, tough, that an average of 10-15 minutes and 45-60 minutes can be consumed by car and bus or railway, respectively.

The hypothetical scenario of letting a free and unstopped flow of people through the national borders its considered. Hence, all the connections that cross any of the borders previously mentioned are modified by applying this reduction of trip time. Later on, the results obtained from the traffic function applied to this new connections is the following:

	Airport	Reality	Model; Scenario G
Share	Belgrade	4,84%	5,17%
	Bratislava	4,24%	3,34%
	Budapest	**31,26%**	**31,61%**
	Cluj-Napoca	4,09%	3,31%
	Vienna	51,45%	51,63%
	Zagreb	4,13%	4,94%
Passengers variation	Belgrade	702.959	3.038
	Bratislava	614.914	-5.130
	Budapest	**4.535.959**	**14.250**
	Cluj-Napoca	593.508	5.942
	Vienna	7.466.099	106.041
	Zagreb	599.138	-1.835
Passengers generated			122.307

Table 20. *Share and passengers variation; Scenario G*

As it is proven, the amount of total air passengers is heavily favored from this alteration of the system. As the function suggested, an decrease in the journey time has a positive impact in the total traffic flow. From all the scenarios results, it actually denotes the best and positive overall impact in the generation of air passengers in the region.

The reason of this positive results lies in the almost equal and homogeneous improvement of the connections, no particularizing any airport. However, note that there is quite different results when focusing on specifics airport outcome.

Bratislava and Zagreb have a deficit in the passengers variation. Belgrade, Budapest and Cluj-Napoca, on the other hand, show a slight increase of its air passengers production. Far from the others, Vienna's airport registers a great variation. The fact that Bratislava and Zagreb are the airports with less direct commercial flights to the twenty-two destinations and from the six departing airports studied and that Vienna doubles this total amount compared to the others, may be determinant in these results.

It is interpreted that the attractiveness and likeliness to fly from an specific airport is strongly related to how good the connection to other destinations is. And this relation is more than proportional to the traffic generated. For example, Budapest is a little bit more than half-connected than Vienna but still the second generated more than a 6-times increase.

However, the "catchment area" shows no change from the Base Scenario, Fig. 4 and Fig. 5. Thus, it can be interpreted that; The better the connectivity the more sensitive to a time reduction in the access to the airport and that the relative time is responsible for such a loss for Bratislava and Zagreb more than a fact of losing a geographical influence stake.

6.8. Scenario H; The Euro becomes the Hungarian currency

An other issue soon to be faced is the adoption of the Euro as the Hungarian currency in detriment of the Forint. It is suggested (Brouwer, Paap, and Viaene, 2008) that the introduction of the Euro would increase foreign investment in Hungary by a 30%. In general terms, it is expected to have a positive impact on Hungarian's economy. As a result of that and thanks to a survey conducted in April 2015, 60% of Hungarians are in favor of introducing the Euro while a 35% is against (TNS Political & Social at the request of the European Commission, Directorate-General for Economic and Financial Affairs (DG ECFIN), 2015).Note that it differs by a 5% from 2014 survey.

However, the way it is related to our abstract aggregated model function is through the GDP per capita variation and the inflation. So, the aim of this scenario is to have a better approach to the consequences of this issue on the air passengers traffic in the studied region. In order to do so, connections remain the same and GDP per capita and some fares are affected.

The change in the GDP per capita is deduced from other recent countries that have incorporated the Euro. Those studied countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Spain and Netherlands. By the late 90s, all of them accepted the new currency. The purpose is to understand the relation of the introduction of the Euro and the slope 's change on the GDP per capita's trend. So, including Hungary, this is the average variation of the GDP per capita (The World Data Bank, 2016) two years before and two years after yielding the Euro. In the case of Hungary, data is considered since 2010:

County	Before	After
Austria	2,77%	3,25%
Belgium	2,61%	3,35%
Finland	3,56%	5,54%
France	1,37%	2,58%
Germany	0,98%	1,83%
Ireland	8,94%	9,14%
Italy	1,68%	2,6%
Spain	3,68%	4,18%
Netherlands	3,82%	3,92%
Hungary	1,33%	-

Table 21. *Variation of the GDP per capita before and after introducing the Euro as the national currency* **(The World Data Bank, 2016)**

Despite how volatile the situation can be and as long as every scenario may be bound to different ties and conditions, it is decided to apply an average of the previous 10 examples GDP per capita's change to the Hungarian current trend. So, all the administrative regions considered in the present paper now have an increase of its GDP per capita. On the other hand, inflation matters as well. The procedure has been quite similar, looking into those countries' inflation (The World Data Bank, 2016) evolution two years before and two years after introducing the euro. Again, Hungarian data is considered since 2010:

County	Before	After
Austria	1,12%	1,48%
Belgium	1,29%	1,83%
Finland	1,30%	2,23%
France	0,91	1,12%
Germany	1,41%	1,02%
Ireland	1,93%	3,60%
Italy	2,00%	2,09%
Spain	1,90%	2,87%
Netherlands	2,08%	2,25%
Hungary	2,65%	-

Table 22. *Variation of the inflation per capita before and after introducing the Euro as the national currency* (**(The World Data Bank, 2016)**

So, in that case, the average change of the 10 studied countries inflation is applied to the connections. It is assumed that it only affects to the prices of the connections whose origin is in Hungary. Furthermore and as long as air fares answer to some other reasons, the price of flying from Liszt Ferenc International Airport remains the same. All together, the results obtained after applying our traffic modeling function are the following:

	Airport	Reality	Model; Scenario H
Share	Belgrade	4,84%	5,14%
	Bratislava	4,24%	3,35%
	Budapest	**31,26%**	**31,64%**
	Cluj-Napoca	4,09%	3,29%
	Vienna	51,45%	51,66%
	Zagreb	4,13%	4,91%
Passengers variation	Belgrade	702.959	-4.178
	Bratislava	614.914	-6.769
	Budapest	**4.535.959**	**-6.367**
	Cluj-Napoca	593.508	462
	Vienna	7.466.099	70.104
	Zagreb	599.138	-7.967
Passengers generated			45.285

Table 23. *Share and passengers variation; Scenario H*

The results suggest that the system is more sensitive to the variation of the price rather than the change in the GDP per capita. In that sense, Vienna happens to have the best outcome as a result of the more expensive access to the airport of Budapest. Note that most of the region considered is inside the boundaries of Hungary. A more expensive access to Liszt Ferenc International Airport is translated as a reduction of Vienna's relative price and consequently an decent increase in its traffic. As for the others, all of them except Cluj - Napoca have losses in the total amount of air passengers. It is mainly because some populations in the western region of Hungary that in the base scenario could chose to fly from Zagreb, Bratislava or Belgrade, now have a bit more expensive access. Finally, mention that the "catchment area" (Fig. 4 and Fig. 5) remains the same despite the variation of the prices in some cases.

7. CONCLUSIONS AND FUTURE APPLICATIONS

As a way of summarizing the general conclusions extracted from all the scenarios, it is necessary to split them into model conclusions and socio-economic and geographical conclusions.

Regarding to the model, it has fulfilled the basic requirements specified back in the literature review. However, the main concern that has been tried to solve is the aggregated data usage. The traffic modeling function comes from a modeled aggregated data that predicts and shows quite well totals and shares in an overall system. Yet it has a long way to provide a 100% reliable output. Unfortunately, it has no major effect when individualizing or focusing in particular cities nor special routes. Pointing Budapest as an example, it displayed that the majority of population would fly from Vienna instead of Budapest, and that is false. Despite the amount of straight connections having quite a weigh when predicting air passenger traffic, it is doubted that it is so determinant over the rest of parameters. This fact has led to experiencing few changes due to alterations in the rest of parameters. On our side, we would need to adjust and caliber the function for each and every city, or at least every region. Put it all together depending on people's preferences, sensibilities, kind of city, country, etc. Its not only about population, GDP per capita, price, time and connections.

Jumping from an abstract aggregated model to, for example, a continuous modeling approach would mean such a quantum leap that all those social-economical parameters could be recognized. Further studies run after the right and available data should follow this path and consider it for different regional models now to be commented.

Another limitation adopted to simplify the study is that waiting times ere not considered, and surely is something that should be taken into account in further studies if prioritizing the route selection. The waiting time depends on each and every possible route from all of the origins, and this is something not feasible with the available data. Hence, it is assumed as well that in the access city to airport, waiting time, boarding time, check in time and process, airport likes, etc. there is not any waiting time. It is acknowledged that it is something that now rules as a main role in the airprot's choice as a matter of the utilities it may provide better than the others but, as it was said, it was deemed to many and different airports whose values might defer that much that further studies are required to solve it. Route selection could also lead to another improvement for deeper knowledges, no matter the characteristics of the approach. Congestions, wether having arcs in the system (maximum flow) or through a continuous model, surely have something to say in this matter. Specially in the city-to-airport connections.

The "catchment area" of each airport was particularized only to fare and time parameters. It is quite unfair because it does not represent the current area of influence linked to every airport. However, as long as the connection origin-destination is split into origin - departing airport, departing airport – arriving airport and arriving airport – destination, it is reasonable representing what has been altered in the present paper, the access to the airport. Furthermore, the characteristics studied from the access to the departing airport have no relation with the access to de arriving airport. The characteristics of the departing and arriving airports connections are more dependent on airlines and their fare, price, seats and destinations offered rather than the access to the airport. That is why, despite providing a good access to an airport, it is not necessarily translated as an improvement of the catchment area. From that point and simplifying ties in the process, it was decided to show the variations on the mentioned "catchment area" from the alterations the present paper suggests just accessing to the airport. As it is stated, "it is unusual for airport service areas to overlap and even more unusual for an overlap to be considered in the forecasting process" (Rubin & Fagan, 1976, p. 1). They now do overlap in short time lapses as they the characteristics provided by every airport are in constant change and this is definitely something to deeply consider in further studies.

Finally, it is worth to highlight how large isthe effort of forming the network system and the time spent checking the feasibility of the flow at equilibrium point for a dense system.

In relation to the socio-economic and geographical conclusions. the present paper handled some valuable information worth to be considered for future approaches. Firstly and probably in a lower degree than the observed, connectivity proves to rule in the air traffic flow. Connectivity represented as the total amount of destinations and total direct connections to those destinations available from an origin. The total direct commercial flights, despite having low influence relatively on the other variables, prove to have more importance on the air passengers traffic than air fare or trip time. And that is why many emergent and recent routes have been launched in the region, specially through Wizz Air. As an example of that and the growing connecting needs, Skyscanner's (Airline Network News and Analysis, 2016) revealed its unserved route of the week back in February 17, 2016. There is no straight connection Budapest-New York at the moment. There used to be one in 2011, before the national Hungarian Airline bankrupted and lost the relationship with American Airlines, the operator of the service. Sky scanner suggests that more than 275.000 searches took place in 2015 despite being not a direct connection. From all of those, an average of a 12% was translated into a ticket purchase. That's an awesome hint of the latent necessity since the average purchase ticket per search registered in Skyscanner database is about 9,3%. Since American Airlines stopped operating the route, London Heathrow (13%), Paris CDG (12%) and Frankfurt (11%) have been the main global hubs in charge of accomplishing the connection.

Acknowledging how important is the connectivity, given the recent reshaping of the metropolitan area of Budapest and adapting to the social and economical needs, it is encouraged to approach the study from a completely different perspective, the business model and its impact on the access to the airport. The 2014 Hungarian Regional Development Plan leans towards three proposed scenarios that could be applied to Budapest; airport city, airport corridor and intermodal hub. The three of them would shape differently the city of Budapest and have a different output on the air transportation system. Nevertheless, they all can be interpreted as a mid-long term milestone, specially the airport-city. Prior to that, the macro-regional corridors should promote this "multi-polarization". By macro-regional corridors are understood the connection between the city center of Budapest and the airport through all the thematic modes and the previously mentioned potential corridors connecting Budapest with the South East Hungary and the Carpathian Basin.

From one side or another, every conclusion just proves that "connectography" is heading to empower airports as individual entities that can sustain themselves and even supplant the cities role in the former air transportation conception. All the scenarios showed that improving the connection to the airport has a positive impact in terms of the air passengers traffic. However and from an aggregated point of view, improving the connection of Budapest is not necessarily a synonym of a major passengers flow. Selfishly, it does not seem a good idea linking better Budapest but the airport of Budapest to the rest of the cities.

Finally, it is believed that Budapest is just a short step far from truly challenging Vienna in the dominance over the region. Developing the Budapest-Airport corridor, leaning towards a better connection with the South and the East and establishing route partnerships with Vienna and Bratislava would place Budapest in the forefront of Europe. It is just a matter of thinking big. Once it happens, the rest will come right after that.

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